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THE DECAY THEORY OF IMMEDIATE MEMORY AND PACED RECALL[1]

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ONE of the more intractable problems in studies of immediate memory is how to assess the relative importance of time lapse and distraction. The arguments are in general well known and inconclusive, not least because providing distracting material inevitably involves time lapse.

Drawing largely on Brown's data (2), Broadbent (1) describes a simple model for immediate memory which is based on an assumption of decay theory and accounts for many otherwise isolated facts. The status of decay theory in general, and of the validity of this model, would obviously be clarified if a technique of experiment could be used permitting distraction to be held constant, the interval between presentation and recall to be varied, and rehearsal during this interval to be reduced to a minimum.

Control of the interval between presentation and recall of digits of similar material, composed of discrete items, has usually referred to the interval between the end of the presentation of a complete series of items or message and the beginning of the recall of it. But the interval could also be taken to be the time between the presentation and recall of each individual digit or item in the message. To control this latter interval one would need to specify not only the rate at which the digits were presented, but also the rate at which they were to be recalled, or something very close to it.

Ever since Jacobs' (6) work, it has been recognized that rate of presentation of material might have a bearing on subsequent recall, and Pollack's (7) recent study is the best systematic approach to the topic. Using a mixture of digits and consonants, Pollack reported worsening of recall when presentation speeds were increased from 15 to 96 items a minute. This he attributed to the decreasing opportunity for rehearsal between items. Above this rate he found little change, and this fact is damaging to decay theory, which would require that decreasing the interval between presented items should reduce forgetting.

Since neither Pollack's nor Brown's evidence refutes decay theory, and since the effect of the interval between presentation and recall is so

[1]The authors are most grateful to the General Post Office and to the Union of Post Office Workers for providing the facilities for testing.

critical for the success of the theory, the experiment to be described had the primary aim of subjecting the theory to further test. A secondary and more practical aim was to test a prediction which would follow from it, namely that unpaced recall is superior to paced recall. This latter question has relevance to the design of telephones when numbers exceed the memory span, since the familiar dial-pacing device could practicably be replaced by an unpaced method of transmission if it were found worth while.

Method

The messages used consisted of 8 single digits, drawn from tables of random numbers. All digits from 0 to 9 were used, and the only constraint was that obviously easy sequences were excluded. The messages were recorded on magnetic tape at controlled rates, in a fairly monotonous tone of voice. After each message, the tape was run on to allow time for the subjects' response. Eight messages comprised a block, and after each block time was allowed for the experimenter to inform the subjects what the next block was to be. Two presentation rates were used, 30 and 90 digits a minute.

Three recall rates were used, 30 digits a minute, 90 digits a minute, and unpaced and each was used in conjunction with each presentation speed, making six conditions in all. For the paced recall conditions, a timing device which clicked loudly at the required rate was started by the experimenter as soon as the last digit of a message had been spoken. It was stopped after eight clicks. During recall under paced conditions, subjects were closely watched by the experimenter to ensure that they did in fact keep in step with the timer when writing their responses on specially prepared score sheets. The few subjects who were unable to manage the paced recall conditions were excluded from the results. For the condition of unpaced recall there was no timer.

The 30 female subjects, all telephone operators, were tested in groups of approximately 10. Their age range was 15 to 35 with a median of 20. All had volunteered for the experiment, which was carried out during working hours. Since the subjects were well aware of the memory requirements for handling telephone numbers they responded co-operatively to a general briefing along those lines. The test tape began with several practice messages with paced recall, and the test was begun only when it was clear that the instructions had been understood.

The 6 test conditions were as follows:

A. Fast presentation–fast recall (*FF*)
B. Fast presentation–slow recall (*FS*)
C. Fast presentation–unpaced recall (*FU*)
D. Slow presentation–fast recall (*SF*)
E. Slow presentation–slow recall (*SS*)
F. Slow presentation–unpaced recall (*SU*)

The conditions were given in the order ABCDEFFEDCBA. There were thus 12 blocks of 8 messages each, and the test took 44 minutes.

Under the 6 conditions described above, the intervals between presentation and recall of individual digits were as follows:

FF–Interval between presentation and recall equal for all digits at about 6 seconds

SS–Interval between presentation and recall equal for all digits at about 17 seconds

FS—Interval between presentation and recall varied, from about 7–17 seconds; the earlier the digit in the message, the shorter the interval

SF—Interval between presentation and recall varied, from about 6–17 seconds; the earlier the digit in the message, the longer the interval

In the *FU* and *SU* conditions duration of the interval was not known, since there was not temporal constraint in recall, but it can be assumed that any given digit waited longer in the *SU* condition.

Results

Table I gives the percentage of messages which were correctly recalled —correct digits in correct order—and also shows the average delay between presentation and recall of individual digits for each condition.

TABLE I

Percentages of Messages Correctly Recalled under the 6 Conditions, with Mean Delay between Presentation and Recall of Individual Digits for Paced Recall Conditions

	Presentation rate			
	Fast		Slow	
Recall rate	Percentage correct	Mean delay (secs.)	Percentage correct	Mean delay (secs.)
Fast	41.0	6.0	39.6	11.75
Slow	35.0	12.25	32.1	17.0
Unpaced	62.3	—	42.9	—

To normalize the data, angular transformations were made of the proportions in Table I, using Fisher and Yates' (5) tables, and Duncan's multiple comparison test was applied for a 5 per cent level of significance (4). The most crucial comparison for testing decay theory is between the *FF* and *SS* conditions, since a digit in any given serial position waits nearly three times as long under *SS* as under *FF* conditions. Recall is significantly better under the *FF* conditions.

A second important comparison is between the *FS* and *SF* conditions. In these two, although each digit waits a different time between presentation and recall, the average waiting time for all eight digits is nearly the same. The difference between the percentages in Table I is not statistically significant. Of the remaining four possible comparisons (excluding the unpaced recall conditions) there are significant differences in two (*SF-SS* and *FF-FS*), while the other two show differences which are in the expected direction but not significant at the 5 per cent level.

Further evidence in support of the decay theory comes from comparing the *FU* and *SU* conditions. All digits, except perhaps the last, wait for a shorter time when the presentation rate is fast. In this condition the proportion of messages successfully reproduced is significantly better. In general, all differences are in the direction expected from decay theory.

It was argued in the Introduction that, if decay theory were valid, recall under paced conditions would be inferior to recall under unpaced conditions, and it is only reasonable to test this with comparable speeds of presentation. The following further comparisons can be made from the data in Table I: *FU–FF*; *FU–FS*; *SU–SS*; *SU–SF*. In all except the last one, performance is significantly superior when recall is unpaced, and in the last the difference is in the predicted direction.

Not only the messages, but also the individual digits were scored as correct or incorrect, and familiar serial order effects were found for all conditions. The last digit was the most successfully recalled, the first digit coming next. When digits in the same serial position were compared for the different test conditions (but excluding the *FU* and *SU* conditions, where time of recall was not strictly known), digits which waited longer between presentation and recall were almost always recalled less successfully. This effect was particularly marked when the *FF* and *SS* conditions were compared. In every serial position *SS* digits waited about three times as long as *FF* digits, and at each position there were about 50 per cent more errors with the longer interval.

Discussion

The attempts by Brown (2) and others to assess the relative importance of decay theory by interposing a task between perception and recall have not been conclusive. Brown found that, if he increased the amount and hence the duration of the interpolated task, there was a consistent memory decrement. But increasing the duration alone did not produce a decrement, probably (Brown thought) because it permitted some rehearsal.

The present experiment clarifies matters considerably. No other material was interposed between presentation and recall of the message; the varying delays were obtained by changing the presentation rates and controlling the rate of recall. In so far as listening to or recalling the message can be regarded as an interpolated task, the condition was achieved in which amount was constant, duration varying, and rehearsal minimal. It is clear that when the duration increased there were more recall errors. It may be that at the presentation rate of a digit every two seconds some subjects rehearsed to some extent. In spite of this, with

recall rate constant, slow presentation rates always led to more failures. The same might be said about rehearsal during slow recall rates; if it occurred, it did not help sufficiently to overcome the losses here attributed to decay.

In the conditions with unpaced recall performance inevitably reflects the results of processes during perception. These processes would differ when the presentation rates differed. Rehearsal would be rehearsal of the results of the processes, and once rehearsal had occurred subsequent conditions should be relatively unimportant, though in this case they were similar. Rehearsal after a message arriving slowly would consolidate a message which would be less perfect than one based on rapid arrival.

One account of the effect of rehearsal has been provided by Broadbent (1) who sees it as a process akin to a "re-circulation" of stored information. However, what is "re-circulated" is not necessarily a perfect representation of the original stimuli. Decay theory implies that, without rehearsal, stimuli begin to decay immediately after perception. Thus at the end of a fast presentation of digits, the material rehearsed would be more like the original stimuli than it would be at the end of a slow presentation. As Broadbent's model suggests, it is unlikely that rehearsal can re-create what has already decayed.

There is a different course of events when recall is paced. In these cases, rehearsal of what is left of the complete message is prevented, and the decay process continues until the digit is required. In this case one would expect what was found: for digits in a given serial position, the longer the delay the greater the probability of memory failure.

The results have also confirmed the prediction that unpaced recall would be superior to paced recall when presentation rate was constant. Unpaced recall has several advantages. First, recall itself can almost certainly be completed more quickly than even the fast paced condition permitted. Secondly, it is known that in other tasks subjects perform better when they can time responses in accord with the mental processes which underly them than when they are forced to respond at moments determined by external factors (3). Thirdly, and perhaps most important, there is opportunity for complete rehearsal immediately after the end of the presentation of the message. When recall was paced, the first digit was required almost immediately after the last digit had been presented. Rehearsal between these two events can be ruled out.

In general then, the results of this experiment strongly support the view that, in the absence of rehearsal, memory decays very rapidly with time. Associated with the evidence is the expected finding that, when recall is paced, it is not as good as when it is unpaced. Finally, and in conflict with previous workers (7), it was found that a fast presentation

rate gave a higher proportion of correctly recalled messages than a slow rate. The last point would appear to merit further consideration, since it is important theoretically that the role of rehearsal during perception should be clarified.

Summary

Immediate memory for 8-digit numbers was tested under novel conditions involving paced and unpaced recall. The method was such that the interval between presentation and recall of digits could be varied without introducing an interpolated task. It was found that increasing the interval between presentation and recall increased errors, that unpaced recall was superior to paced recall, and that fast presentation rate led to fewer errors than slow rate. The findings are interpreted as supporting the theory that in the absence of rehearsal, memory decays rapidly with time.

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STIMULUS DURATION AND PACED PERFORMANCE

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IF STIMULI for serial addition are presented visually, and subjects cannot control stimulus frequency (pacing), they give significantly fewer correct verbal responses and miss increasing numbers of stimuli as pacing is accelerated. Moreover, performance under varying pacing depends also on length of time stimuli are "on" and "off." Experiments demonstrating on-off effects (4) suggest that stimulus duration within a pacing interval may be the principal factor. We were concerned specifically with this possibility.

Accordingly, serial addition performance was studied under three conditions: (1) pacing constant, on-off ratios varied; (2) "on" constant, "off" varied; "off" constant, "on" varied; (3) on-off ratios constant, pacing varied.

These experiments should help to clarify the role of stimulus duration in paced performance and thus the broader problem of its role in "timing" (2).

METHOD

Sixty-one digits from 1 to 9, randomly ordered in a fixed series, were projected under experimental conditions which permitted exposure time for individual digits and rate of presentation to be varied.

The subject was required to add the number before him on the screen to the one that immediately preceded it and to call out his answer. If he made a mistake or missed a number in the series, he could cut back into the series by not responding to one number and adding to it the next one to appear.

Apparatus

A magazine-load automatic projector was used. Each digit appeared on a day-view screen located on a table about 45 inches from where *S* sat. The projected size of each digit was 1 inch. The projector was connected to 2 interval timers so that exposure time for each digit ("on" phase) and interval between exposures ("off" phase) could be independently varied.

All stimuli were on 2×2 glass slides.

The *S*'s responses were recorded by *E* on a prepared answer sheet on which were printed the series of stimuli and correct responses.

Subjects

The 30 *Ss* used in Experiments I, II, and III were RCAF Flight Cadets ranging in age from 18 to 24 years. All had recently been selected for aircrew training, and therefore had at least Grade 12 education. Each *S* had taken an auditory version of the serial addition task one week prior to the experiments. In this pre-training

the stimuli were presented by means of a tape recorder, 1 digit every 1.39 secs. The *S*'s task was identical with that reported here, and his verbal responses were recorded in the same way.

The 25 *Ss* used in Experiments IV and V were Canterbury University College students. All were males between 17 and 28 years. They were, therefore, similar in age and education to the *Ss* used in Experiments I, II, and II. Each *S* took a visual version of the serial addition task before taking part in these experiments. In this pre-training the stimuli were projected, 1 digit every 1.4 secs., with each "on" 0.9 sec. and "off" 0.5 sec. The pre-training was mainly to assure *E* that *S* was familiar with the operations to be required subsequently; evidence presented below supports the view that it had no measurable effects on subsequent performance.

Experiments I, II and III

Experiments I, II, and III dealt with effects of changes in stimulus duration *when pacing was constant.* Frequency of stimulus presentation differed in each experiment, as detailed below.

Experiment I. Pacing constant (1 digit every 1.4 secs.). Stimuli "on" 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1.0 and 1.1 secs., and correspondingly "off" 1.1, 1.0, 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3 secs., giving 9 on-off ratios.

Experiment II. Pacing constant (1 digit every 1.2 secs.). Stimuli "on" 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 sec., and correspondingly "off" 0.9, 0.8, 0.7, 0.6, 0.5, 0.4, 0.3 sec., giving 7 on-off ratios.

Experiment III. Pacing constant (1 digit every 1.0 sec.) Stimuli "on" 0.3, 0.4, 0.5, 0.6, 0.7 sec., and correspondingly "off" 0.7, 0.6, 0.5, 0.4, 0.3 sec., giving 5 on-off ratios.

Ten *Ss*, assigned randomly to each experiment, were given all experimental treatments in random order. A brief interval followed each presentation, and *S* was never told whether his answers were correct.

The *E* recorded correct answers, wrong answers, and stimuli omitted.

Results[1]

A summary of the principal results of analyses of variance of percentages correct obtained under each of the experimental conditions is shown in Table I. As this table indicates, there were no significant differences in percentage correct associated with the various on-off ratios used in Experiments I, II, and III. This means that performance level depended on frequency of stimulus presentation, not on changes in stimulus duration. In these experiments, therefore, the most representative value for each pacing interval is the mean of the percentages correct obtained under each of the on-off ratios. This value was 77.6 when pacing was 1.4 secs. per digit, 64.4 when pacing was 1.2 secs. per digit, and 55.5 when pacing was 1.0 sec. per digit. This decrease in percentage correct with increased pacing is similar to that reported previously (4). It should

[1]In the experiments the data are expressed as percentage correct, and the percentages are then transformed for analysis of variance by the formula: $y = \arcsin \sqrt{\text{percentage correct}}$ (3).

TABLE I

SUMMARY OF PRINCIPAL RESULTS OF ANALYSES OF VARIANCE OF PERCENTAGES CORRECT UNDER 5 EXPERIMENTAL CONDITIONS

Experiment	Source	df	*F*
I	Subjects	9	52.58**
	On-off ratios	8	0.90
II	Subjects	9	12.39**
	On-off ratios	6	1.24
III	Subjects	9	7.64**
	On-off ratios	4	1.69
IV	Subjects	9	34.53**
	Pacing intervals	8	56.48**
V	Subjects	14	9.52**
	Pacing intervals	6	53.99**

**Significant at the .01 level of confidence or better.

be noted that in these experiments the error term remained fairly constant from one experiment to the next, indicating that results were comparable.

In the earlier experiments (4) subjects tended to block rather than make mistakes, and the same tendency occurred in each of the present experiments. It is noteworthy also that stimulus durations as brief as 0.3 sec. (despite pacing differences) were associated with performance characteristic of the pacing interval.

EXPERIMENT IV

Procedure

This experiment, concerned with effects of changes in stimulus duration *with pacing variable*, was similar to (4) but differed in having two basic conditions only. These were: (1) stimuli "on" 0.4 sec., and "off" 0.4, 0.6, 0.8, 1.0 and 1.2 secs. (2) stimuli "on" 0.4, 0.6, 0.8, 1.0 and 1.2 secs., and "off" 0.4 sec.

Thus in 1 session 9 on-off ratios (pacing varying from one digit every 0.8 sec. to one every 1.6 secs.) were given in random order to 10 Ss.

Results

There was a significant decrease in percentage correct with increased pacing in this experiment. This tendency is illustrated in Figure 1, and the relevant portions of an analysis of variance of the results are summarized in Table I. It is clear from these that percentage correct in this experiment depended on stimulus duration as well as pacing. Figure 1

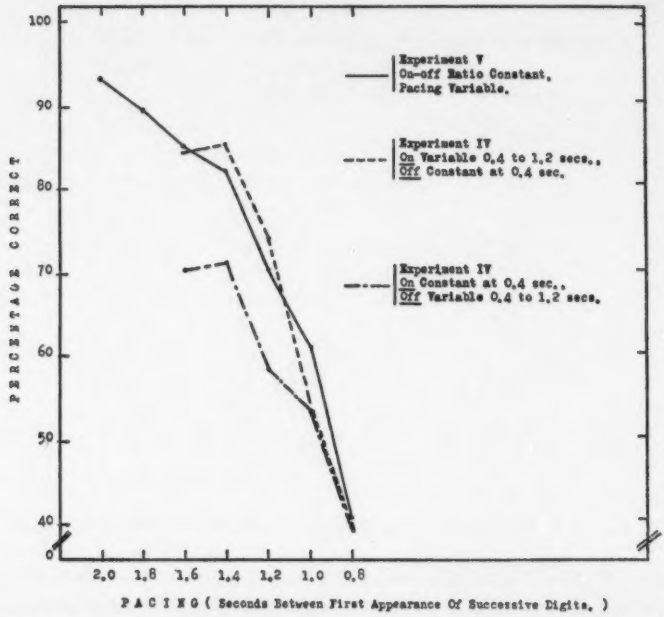

FIGURE 1. Performance of 25 male college students on the serial addition task with pacing and on-off ratios varied.

also illustrates the fact that prolonging stimulus duration resulted in significantly more correct answers (when comparisons were made within each pacing interval) until pacing reached the frequency of one digit every 1.0 sec. Under the latter condition pacing was the most important variable in performance.

Once again Ss blocked more frequently than they made mistakes, and there was a disproportionate increase in these blocking errors (omissions) with increased pacing, as compared with increase in wrong answers. Finally, the error term in the analysis of variance of these results was comparable to those of the other experiments, indicating comparable performance.

EXPERIMENT V

Procedure

On-off ratios were constant, and pacing varied. The on-off ratios were: 0.4 to 0.4: 0.5 to 0.5: 0.6 to 0.6: 0.7 to 0.7: 0.8 to 0.8: 0.9 to 0.9: 1.0 to 1.0 secs. This gave 7 pacing conditions, ranging from 1 digit every 0.8 sec to 1 every 2.0 secs

In all 15 Ss took part in the experiment.

Results

In Experiment V there was a significant decrease in percentage correct (Table I) with increased pacing, and this decrease was similar to that which occurred in Experiment IV when the "on" phase was varied with every change in pacing while the "off" phase remained constant at 0.4 sec. (Figure 1). This trend lends support to the view that in Experiment IV performance was influenced by changes in stimulus duration as well as pacing, and not by changes in on-off *ratios*. It is worth noting that although on-off ratios were constant in Experiment V, stimulus durations decreased with increased pacing as in Experiment IV. In Experiment IV, however, the changes in stimulus duration were accompanied by similar changes in "off" phase as well.

Once again *Ss* blocked more than they gave wrong answers as pacing increased, and the error term in the analysis of variance was similar to that of the other experiments. This is evidence that the performance of the group used in Experiment V was comparable to that of the groups used in the other experiments.

Discussion

Experiments I, II, and III, show that *with pacing constant* and stimulus duration varied, percentage correct on the serial addition task depends on stimulus frequency and not on stimulus duration, within the limits of durations studied. Stimuli can be "on" at least as briefly as 0.3 sec. or as long as 1.1 secs. under these conditions without significant effect on performance. It is clear that correct answers in these experiments did not depend on stimulus duration.

Experiments IV and V confirm the suggestion of earlier findings (4) that when various pacing intervals are *presented randomly* performance depends both on stimulus duration and pacing. However, in Experiment IV the role of stimulus duration in on-off effects was revealed more clearly, and shown to have been a major factor in the previously reported on-off effects.

At first glance the results of Experiment IV also suggest that prolonging stimuli facilitates performance under varying pacing. However, when the results of this experiment are considered in conjunction with those of Experiment V this interpretation seems unlikely. It seems more probable that prolonging stimuli under variable pacing conditions sustains rather than facilitates performance (Figure 1).

Consider now the problem of retarded performance in Experiment IV. The lowest percentage correct in this experiment occurred with stimulus duration constant at 0.4 sec. and "off" phase variable, despite the in-

crease in "rest interval" between stimuli. In view of the results of Experiments I, II, and III, it would be difficult to attribute this effect to the "on" phase being too brief for stimuli to be apprehended. These experiments show, on the contrary, that even shorter stimuli (0.3 sec.) were effective. One possibility is that longer stimulus durations permitted S to respond and glance again at the stimuli before they changed, while briefer durations did not. If this were so, it would mean that in the latter case S would have to remember the number just seen in order to respond to the next in the series. The relatively poor performance in this part of Experiment IV suggests that variable pacing disturbs immediate memory, and that this disturbance was minimized in the experiment by prolonging stimulus duration in some cases, thus permitting the stimuli to serve a mnemonic function.

Finally, the disproportionate increase in frequency of omissions with increased pacing (Experiments IV and V) was of the same order as that reported previously (4), and adds additional support to the view that variable pacing results in memory disturbance rather than response interference.

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FACTORS AFFECTING THE FINAL DECISION IN THE EMPLOYMENT INTERVIEW[1]

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IMPROVEMENT in selection techniques requires research in two directions: (*a*) studies of reliability and validity to check on their effectiveness; (*b*) studies of the measuring instruments to provide a basis for their systematic improvement.

Wagner's review (**6**) shows that in the employment interview there has been a modest amount of research dealing with reliability and validity. Apart from studies of expressive movement and empathy (e.g., **1, 2, 3**) which can be related to the selective functions of the interviewer, little has been done experimentally to determine how the interview functions as a selective device. This study is directed to that end.

The measuring instrument in the interview is a person; because of known individual differences, it might be assumed that there is no common measuring instrument to be studied. However, there are psychological processes which underlie decision-making in the interview. If these can be identified, and prove to be lawful, they may provide the means for understanding, and perhaps improving, the selective functions of the interviewer. Without some systematic attack on this problem it seems unlikely that steady progress can be achieved comparable to that made in the field of testing.

The function of the interviewer is to secure information, evaluate it, and come to a final decision. The evaluated items of information are somehow summated or integrated to arrive at this decision, the essential nature of which is to accept or reject. The decision is roughly comparable to the final score on a test; hence we may look upon the search for an understanding of decision-making as similar to the identification of sources of variance contributing to the final score on a test. The specific aim of this investigation is to make a start at identifying the factors which affect the final decision in the interview.

An initial investigation of this problem should study variables that are of sufficient importance to manifest themselves in practical situations. To ensure this the total interview must be left intact, and should ideally

[1]Based on a thesis submitted to McGill University in partial fulfilment of the requirements for the Ph.D. degree, 1954. The author gratefully acknowledges the advice of Dr. E. C. Webster, and financial assistance from the Defence Research Board (Grant no. 9435-53 to E. C. Webster).

involve a sample of actual interviews seriously concerned with the selection of applicants.

In such a setting certain gross variables can be identified if the interviewer's function is thought of as securing and evaluating information. Different kinds of information are identifiable; the evaluation placed upon these kinds of information can be ascertained; the order in which these kinds of information are communicated can be controlled.

The information received by an interviewer may be subsumed under two categories: (*a*) that communicated by language; (*b*) that communicated by direct perception of the applicant. In the majority of interviews the completed application form provides the only information communicated by written language. The physical presence of the applicant provides the opportunity for securing information by direct perception. The active interview contributes information both from spoken language and direct perception.

If the application form and the appearance of the applicant are assessed independently, and if the order in which they are assessed is alternated, it is possible to determine: (*a*) the contribution of these sources of information to the final decision; (*b*) whether the order in which they are assessed affects final outcome; (*c*) whether the different evaluations (acceptance or rejection) placed upon them are differentially related to final outcome; (*d*) by inference, the contribution of the active interview to the final decision. The experiments which follow were designed to secure relevant data.

Methods

Two experiments were carried out; one in an industrial and one in a military setting.

The Industrial Experiment

The applicants in this experiment were being seriously considered for specific jobs. This involved the co-operation of 4 companies representing manufacturing, transportation, public utilities, and retail selling. In all, 48 applicants were each interviewed by 2 interviewers, making a total of 96 interview decisions; 12 interviewers (6 pairs) were used. The procedure was as follows.

1. Applicants presenting themselves at the employment office were given a preliminary screening to ensure that: (*a*) they were applying for a specific job, and (*b*) they were not hopelessly unsuited. The screening interviewer was not involved in subsequent appraisal.

2. In appraising a given applicant one interviewer actively communicated with him, the other listened and observed in a completely passive role.

3. Each interviewer judged the suitability of the applicant on the basis of: (*a*) application form, (*b*) appearance, (*c*) total impression on completion of the active interview. There was no communication between the interviewers with respect to the ratings they made. They were asked to make ratings (*a*) and (*b*)

independently, that is, in rating the application form they were asked to disregard the previous rating on appearance, and vice versa.

(4) Each pair of interviewers was assigned eight applicants, who were appraised under the conditions described below.

The two interviewers alternated in the active and passive roles. Two applicants were rated in the order *application form–appearance–final* by both interviewers; two were rated in the order *appearance–application form–final*; each of the remaining four was rated in one order by the first interviewer and in the other order by the second interviewer. In this way there was a counterbalancing of the order of information input with the interviewers' active and passive roles.

The Army Experiment

Eighteen experienced army personnel officers each assessed the same three applicants for C.O.T.C. training in a specific regiment. As in the industrial experiment, assessments were made of application form and appearance. The "interview" took the form of a standard personal history as described below. The following materials and subjects were used in all sessions.

(*a*) Three university students selected by a former C.O.T.C. commander, on the basis of their appearance only, as "very good," "average," and "dubious," respectively.

(*b*) Three application forms which could reasonably apply to all three applicants. These were prepared in co-operation with the Chief Army Personnel Officer in Montreal, one being designed as "very good," one "average," one "dubious."

(*c*) Three personal histories which could reasonably fit the facts of all three application forms and the appearance of the three applicants. These too were designed to be "very good," "average," and "dubious." The information in the personal histories was communicated by supplying the interviewers with mimeographed copies and also having the applicant read the data aloud to them.

In the experiment each applicant appeared in conjunction with every possible combination of application form and personal history. For each order of information input there were 9 possible combinations for each applicant; for the 3 applicants, a total of 27. Here 2 orders of information input are reported,[2] giving a total of 54 interview decisions.

The army experiment was designed to study the same factors as the industrial but with the variables more rigorously controlled. The two experiments together offer the advantages of both laboratory and real-life situations.

Results

For convenience in reporting, the following notation has been used in Table I, and also in the text where it seemed preferable to complete verbal description. A.F., App. and F stand respectively for application form, appearance, and final judgment; "a" and "r" after these symbols indicate ratings of acceptance and rejection; 1 and 2 after the symbols indicate that the rating was made in first or second place in the information series. Thus A.F.r.2 indicates a rating of rejection on the basis of the application form when it was rated second (i.e., after App.).

[2]Additional data in the thesis, derived from nine additional personnel officers rating information in the order personal history–application form–appearance, yield results in line with those reported here and strengthen the statistical case.

TABLE I

AGREEMENT OF APPLICATION FORM (A.F.) AND APPEARANCE (App.) RATINGS WITH FINAL (F) RATINGS

Information rated	Industrial experiment		Army experiment		Combined	
	N	% agreeing with F	*N*	% agreeing with *F*	*N*	% agreeing with F
			A			
All A.F.	96	81.0	54	77.7	150	80.0
All App.	96	62.4	54	79.6	150	68.7
			B			
A.F.1	48	87.5	27	88.9	75	88.0
A.F.2	48	75.0	27	66.6	75	72.0
App. 1	48	64.8	27	70.4	75	66.6
App. 2	48	60.5	27	88.8	75	70.7
			C			
A.F.a.1	23	82.7	23	86.9	46	84.4
A.F.a.2	24	58.3	23	69.6	47	63.8
A.F.r.1	25	92.0	4	100.0	29	93.3
A.F.r.2	24	91.6	4	50.0	28	85.7
App.a.1	31	48.8	22	72.7	53	58.5
App.a.2	36	52.8	23	86.9	59	66.1
App.r.1	17	94.1	5	60.0	22	86.4
App.r.2	12	83.3	4	100.0	16	87.5
			D*			
A.F.a-App.a	20	90.0	22	90.9	42	90.5
App.a-A.F.a	18	72.2	20	75.0	38	73.8
A.F.a-App.r	3	33.3	1	00.0	4	25.0
App.r-A.F.a	6	16.6	3	33.3	9	22.2
A.F.r-App.a	16	93.7	1	100.	17	94.1
App.a-A.F.r	13	84.6	2	50.0	15	80.0
A.F.r-App.r	9	89.1	3	100.0	12	91.7
App.r-A.F.r	11	100.0	2	50.0	13	92.3

*Figures are percentage of A.F. ratings agreeing with F ratings under the conditions shown.

Table I shows the results of the two experiments separately and combined. Section A shows the relative efficiency with which A.F. and App. ratings predict F ratings; B repeats A but adds the variable "serial order"; C repeats B but adds the variable "nature of the evaluation"; D arranges

the data so that the effects of serial order and nature of the evaluation can each be assessed with the other variables held constant. Results reported in the text are for combined data, with one exception which is specifically noted. Consistency of results in the two experiments may be judged from the table.

1. *Relation of Application Form and Appearance Ratings to Final Ratings*

The accuracy with which A.F. and App. ratings predict F ratings does not depend only upon the difference in kind of information rated. Serial order and the nature of the evaluation (accept or reject) also play a part.

When kind of information alone is considered and all A.F. ratings ($N = 150$) are compared with all App. ratings ($N = 150$), the former predict F ratings with 80 per cent accuracy, the latter with 68.7 per cent ($t = 2.294$, $P < .05$).

When serial position is taken into account the superiority of A.F. over App. ratings holds only when A.F. is rated first. A.F.1 correctly predicts F 88 per cent of the time, App.1 66.6 per cent ($t = 2.184$, $P < 0.5$). Corresponding figures for A.F.2 *vs.* App.2 72.0 and 70.7 per cent (difference not significant).

When the nature of the rating is taken into account the superiority of A.F.1 over App.1 holds only for A.F.a.1 *vs.* App.a.1. Accuracy scores here are 84.8 and 58.5 per cent respectively ($t = 2.858$, $P < .01$). None of the comparisons A.F.r.1 *vs.* App.r.1; A.F.a.2 *vs.* App.a.2; and A.F.r.2 *vs.* App.r.2 shows a significant difference.

2. *Ratings of Acceptance and Rejection on A.F. and App. in Relation to F Ratings*

The percentages quoted in this section are derived from Table ID, sources being indicated in brackets.

When applicants received both A.F.a and App.a ratings, regardless of serial order, they secured F.a ratings 82.5 per cent of the time (Table I D, lines 1 and 2 combined). Similarly, when the ratings were A.F.r and App.r, an F.r rating followed 92 per cent of the time (lines 7 and 8 combined). If either A.F. or App. was rated reject, an F.r rating followed 84.5 per cent of the time (lines 3,4,5,6 combined). In lines 3 and 4 and percentages finally rejected will be 75 and 77.8, i.e. 100-25 and 100-22.2.

If A.F. and App. are considered separately, it is apparent that being *rejected* on these is a more powerful determinant of the final outcome than being *accepted*. Ratings of A.F.a and A.F.r predict F ratings 70.8 and 89.5 per cent respectively (lines 1,2,3,4 *vs.* 5,6,7,8) ($t = 2.483$, $P < .02$). Corresponding figures for App.a and App.r are 62.5 and 86.8 ($t = 2.835$, $P < .01$).

Two things may be inferred from the above data: (*a*) unless accepted on *both* A.F. and App., the odds against final acceptance are roughly 10 to 1; (*b*) the active interview is primarily a search for negative evidence.

3. *The Role of the Active Interview*

On the basis of the present data ($N = 150$), if final acceptance is predicted when both A.F. and App. are rated acceptable, and final rejection in all other cases, the accuracy of prediction is 85 per cent. The same prediction when A.F. is rated first (which is customary) is 88 per cent accurate.

It should be noted that in the army experiment there was no true "active interview." However, in the industrial experiment ($N = 96$), in which serious active interviews were undertaken, corresponding results are 86.4 and 89.6 per cent. The active interview appears to be redundant in most cases.

4. *Series Effects*

Does it make any difference to the final decision whether A.F. or App. is rated first? Relevant data are found in Table I D.

In three of the four comparisons made in the table there is evidence of series effects, that is, A.F. predicts F better when it is in first place. This superiority, however, is significant only in one case: A.F.a — App.a *vs.* App.a — A.F.a *at* $= 2.009$, $P < .05$).

5. *Appearance of Applicants in the Army experiment in Relation to Series Effects*

Additional data from the army experiment contribute some interesting evidence in relation to series effects. The three "applicants" in this experiment were chosen on the basis of appearance alone, one being judged "very good," one "average," and one "dubious." It will be recalled that each appeared for appraisal in conjunction with identical application forms and personal histories; and that there was complete identity of applicants, application forms, and personal histories in the two orders of information input.

In Table II the two columns labelled (*a*) show the number of times each applicant was finally accepted or rejected when A.F. was rated first. Columns labelled (*b*) show corresponding data when App. was rated first.

Chi-square based on columns labelled (*a*)is 1.009, $P < .5$; for (*b*) 6.240, $P < .05$. That is, when A.F. was rated first applicants were not differentially treated with respect to final acceptance and rejection. When

TABLE II

FINAL ACCEPTANCES AND REJECTIONS (IN NUMBERS OF EACH) OF 3 APPLICANTS IN ARMY EXPERIMENT (*a*) WHEN APPLICATION FORM RATED FIRST AND (*b*) WHEN APPEARANCE RATED FIRST

Applicant's appearance	Final acceptance		Final rejection	
	(*a*)	(*b*)	(*a*)	(*b*)
"Very good"	8	9	1	0
"Average"	4	6	5	3
"Dubious"	8	3	1	6

App. was rated first they were differentially treated, the significant shift being largely due to the treatment of the "dubious" applicant.

6. Graphic Summary of Data

To present a somewhat more integrated picture of the main results Figure 1 displays them in graphic form.

The percentage of applicants obtaining ratings of final acceptance is plotted against different orders and different evaluations of the information received from A.F. and App. The plotted line should have a negative slope to the extent that: (*a*) there are *Einstellung* effects, (*b*) application form is more important than appearance in determining the final outcome, and (*c*) ratings of rejection on A.F. or App. make final acceptance unlikely.

DISCUSSION

In attempting an interpretation of the results attention will be focussed on the following four findings: (1) the initial appraisal of information derived from application form and appearance appears to be decisive for the final outcome of a large proportion (85 per cent) of interviews; (2) a rating of rejection on application form or appearance is associated with final rejection 88 per cent of the time; (3) when application form and appearance are both favourably rated the chances for final acceptance are higher if application form is rated first; (4) those who are borderline in appearance are most affected by series effects.

The theoretical considerations which prompted the expectation of series effects in these experiments are those related to *Einstellung* effects (4,5). Here a set is produced in the early part of the experiment which assimilates subsequent materials to it. Finding (1) fits these expectations on

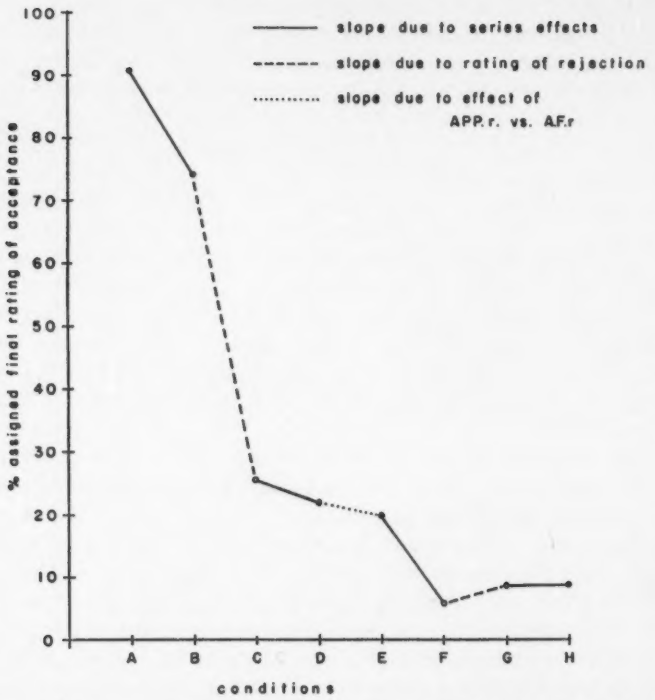

FIGURE 1. Percentage of applicants finally accepted in relation to their assessment on A.F. and App. Conditions: (A) A.F.a–App.a (42); (B) App.a–A.F.a (38); (C) A.F.a–App.r (4); (D) App.r–A.F.a (9); (E) App.a–A.F.r (15); (F) A.F.r–App.a (17); (G) App.r–A.F.r (13); (H) A.F.r–App.r (12); *n* for each condition shown in parentheses.

two grounds: (*a*) evaluations made in the first two or three minutes of the interview are powerful determinants of the final outcome, and (*b*) it is the information on the application form which displays primacy effects. This is to be expected, theoretically, because its information provides a clear-cut framework into which subsequent rather ambiguous information can be assimilated.

However, findings (2), (3), and (4) do not appear explainable in terms of *Einstellung* effects alone. These results do fall into a pattern if, in addition to *Einstellung* effects, there is postulated a permanent set or attitude in the interviewer which affects his sensitivity to, and evaluation of, certain classes of information. What is postulated is a persistent

set or attitude of caution.[3] This is not simply an *ad hoc* affair, for there are grounds for believing that common features of the job engender such an attitude in most, if not all, interviewers.

The system of rewards and punishments applicable to most interviewers emphasizes punishment rather than reward. If the interviewer selects a good employee he typically hears no more about it. If he rejects a good employee, the chances are slight that the error will be discovered. If he selects a poor one, it will be brought home to him. At the least he will have the work of refilling the vacancy; if there is an exit interview he will be concerned with the negative evidence he originally missed; frequently there will be repercussions from the line organization.

To the extent that these forces operate, the interviewer will develop a sensitivity to negative evidence and place a high evaluation on it when coming to the final decision. This would explain finding (2); and, because of *Einstellung* effects, negative evidence found early would exert particularly strong influence.

To account for finding (3) the confidence in the information appraised has to be considered. When the application form is rated first and favourably, the interviewer builds a clear picture which he can communicate to others and defend. The subsequent appraisal of the applicant provides relatively ambiguous material which offers no great resistance to assimilation by the clear-cut conceptual picture he has already formed. None of this information, consequently, arouses the attitude of caution and the active interview is restricted in its probing for negative evidence. The applicant's chances of final acceptance are good.

On the other hand, when appearance is rated first and favourably, the interviewer commits himself to a risk. The tentative commitment is to accept the man, but because of lack of confidence in the validity of the information the attitude of caution is aroused. The appraisal of the application form resists assimilation because of its clear-cut nature, but with the attitude of caution aroused the active interview thoroughly probes for weakness. The consequence is that more grounds for rejection are found when appearance is rated first.

Essentially the same interpretation may be applied to finding (4). In rating the applicant of dubious appearance there are two sources undermining confidence in the tentative decision to accept. The first is lack of confidence in the validity of the information, as noted above. The second is the doubt, in border-line cases, that the appraisal itself is correct. When appearance is rated first, these two factors arouse the attitude of caution and final rejection is all the more likely. When the appearance of

[3]It is interesting that Woodworth and Sells (7) find a general attitude of caution favouring rejection of conclusions in syllogistic reasoning.

the same applicant is appraised against the background of his application form he may actually be perceived differently, and there is apt to be more confidence in the appraisal of his appearance; hence he is more likely to win final acceptance.

Whether or not this interpretation is accepted, the following factual results of these experiments may be stated: (1) the appearance of the applicant and his application form provide information in the first two or three minutes of the interview which decisively affects final outcome in 85 per cent of the cases; (2) information in the application form contributes most to the final decision; (3) in the active interview the interviewer's search is primarily for negative evidence; (4) unless the applicant is assessed favourably on both application form and appearance his chances of final acceptance are very low (about 1 in 10); (5) when both application form and appearance are rated favourably the applicant's chances of final acceptance are better if his application form is rated before his appearance.

Summary

An experimental investigation of the employment interview assesses the influence of the following factors on the final decision: (*a*) information received from the application form and from the appearance of the applicant; (*b*) the evaluation placed on this information; (*c*) the order in which the information is received. It is shown that the final decision is significantly affected by each of these factors. Results are interpreted in terms of *Einstellung* effects and attitudinal determinants of perception.

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PERSONALITY AND MUSCLE ACTIVITY

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MALMO AND SMITH (11), in discussing the results of their research into levels of muscle activity in adult neurotics, suggest that "frontalis-muscle tension may provide an index of something general in the complex we refer to as psychoneurosis." They add: "at this stage in our theorizing it may be useful to adopt (tentatively) a concept like Eysenck's general factor of neuroticism."

The experiment described in the present paper is an attempt to link activity of the skeletal musculature, recorded electromyographically, with the dimensional scheme described by Eysenck (3). In a preliminary study (12) it was found that patients classified on the basis of psychiatric diagnosis as anxiety states, obsessionals, anxious depressives (the dysthymics, in Eysenck's terminology) manifeted a significantly higher level of frontalis and right forearm tension during rest than did a group of mixed hysterics and hysterical personalities. Neurotics of both categories, however, showed a very significant increase in forearm tension during a period in which they were questioned about neurotic symptomatology.

The studies of levels of muscle tension in psychiatric patients are broadly in good agreement. Briefly, these findings include a high degree of frontalis muscle tension (*a*) in mixed neurotics (11), (*b*) in selected anxious, tense patients compared with less anxious patients and normals (13), and (*c*) in dysthymic patients compared with hysterics (12). The differences have been observed during rest, or non-stimulation, and also as a result of both thermal stimulation (11) and verbal questioning (12).

Sainsbury (13) reports significant intercorrelations between arm and frontalis tension in his highly selected group, but the weight of evidence appears to favour the relative independence of these two measures (11, 12).

Most of the groups of patients described in these reports have been characterized by a high proportion of anxiety states or anxiety symptoms. If the finding of differences between hysterics and anxiety states is confirmed, however, it is obvious that results based on mixed neurotic groups will vary with the composition of such groups.

[1]The technical assistance of Mr. S. E. R. Mable and the statistical advice of Mr. P. Slater are gratefully acknowledged.

The problem of sub-classification of neurotics is urgent and difficult; if differences in physiological responsiveness exist within the neurotic category, as appears to be the case, some reliable method of assessing these sub-classes is necessary.

Eysenck and his co-workers, over a period of years, have attempted to place the assessment of personality upon a more objective and reliable basis. As a result of several factor analyses (2) and a discriminant function analysis (7) three dimensions have been described: neuroticism, introversion/extraversion, and psychoticism. In a series of articles Eysenck has attempted to demonstrate that the anxiety state forms the prototype of the introverted neurotic, and the hysteric that of the extraverted neurotic (4, 5, 6).

Recently, item and factor analyses have been made of certain of the Guilford-Martin questionnaires (in particular, the C and R scales) which have high loadings on these factors of neuroticism and introversion, and which differentiate hospitalized neurotics from normals, and anxiety states from hysterics. The results of the analyses have been reported by Eysenck (5) and Franks (8).

It seemed worthwhile to use these more reliable questionnaire measures of personality, rather than psychiatric diagnosis, in conjunction with the physiological recording of muscle activity. (This point will be discussed later.) Only extreme groups, selected from a non-hospitalized population on the basis of scores on the improved scales of neuroticism and introversion-extraversion, were used in the present study which aimed to establish the frontalis and right forearm (extensor) tension levels of four groups: (i) introverted neurotics, (ii) extraverted neurotics, (iii) introverted normals, and (iv) extraverted normals. The terms "neurotic," "introvert," etc., are here used as defined by the questionnaire score.

The programme was also planned to follow up the positive findings of a highly significant increase in forearm tension in neurotic patients, as compared with normals, during a period in which subjects were asked a standard series of questions concerning neurotic symptoms (12). The precise determination of the conditions under which physiological disequilibrium occurs in neurotics is one of the urgent requirements to advance theory in this field. A slight modification of the original procedure was made: "yes" or "no" responses were requested, so that each question could be presented at a standard interval of 20 seconds, and over-all questioning time should not vary from subject to subject.

The design of the experiment also provided information on the correlation between forearm and frontalis tension during the rest and stimulus conditions.

METHOD

Subjects

Four groups of volunteer male university students were selected by means of scores on the two questionnaires. Details are as follows:

Group 1. Introverted neurotics; $N = 18$: Average age 23.8 yrs.; average neuroticism score 17.48 (var. 9.01); average int./ext. score 7.07 (var. 4.22).

Group 2. Extraverted neurotics; $N = 19$: average age 22.3 yrs.; average neuroticism score 15.67 (var. 4.58); average int./ext. score 16.21 (var. 3.79).

Group 3. Introverted normals; $N = 19$: average age 23.7 yrs.; average neuroticism score 7.17 (var. 6.38); average int./ext. score 8.11 (var. 4.09).

Group 4. Extraverted normals; $N = 19$: average age 22.5 yrs.; average neuroticism score 6.36 (var. 8.08); average int./ext. score 16.91 (var. 3.06).

There was no overlap in neuroticism scores between the normal and neurotic groups, or in introversion-extraversion scores between introvert and extravert groups. The age range was 19–37 years; this factor did not influence any of the tension measurements.

Procedure and Apparatus

The questions asked of the subjects were derived from a neuroticism rating scale described in *Dimensions of Personality* (1). There were 11 questions, all concerned with neurotic symptoms (sleeplessness, irritability, etc.). The questioning period was preceded by brief instructions on how the subjects were to make their responses, and by the request that they remain still throughout the session.

The complete experimental procedure, in outline, was as follows: (*a*) Initial rest period–3 min., eyes closed; (*b*) rest–2 min., eyes open; (*c*) rest–2 min., eyes closed; (*d*) instructions–1 min., eyes closed; (*e*) questioning–3 min. 20 sec., eyes open; (*f*) rest–2 min., eyes open; (*g*) rest–2 min., eyes closed.

The periods with eyes open were included in order to obtain a record of eyeblink frequency. These results will be reported separately.

Three single-channel Ediswan electro-physiological amplifiers were employed; the primary tracing was recorded on an ink-writing pen oscillograph unit with a paper speed of 1.5 cm. per sec. This record was monitored so that artefacts, sudden movements, etc., could be noted on the integrated record which was used for scoring. The integrator consisted of a diode pump feeding into a Miller integrator circuit with an anode to grid capacitor of value .01μ fds. and a grid leak of 10 megohms, the valve being EF 37A. The time constant was a little over one second. Thus the integrator gave a continuous (rather than discrete) reading, and the microvolts on the charging capacitor are both difficult to assess at any instant, and not usefully comparable with other workers' figures. Readings were taken from the continuous integrator graph at 5-second intervals; four such readings were used to give an average 20-second score. Logarithmic transformations were effected on these scores both to normalize the data and to render "variability" or fluctuation of the record independent of basal levels (12).

Electrodes were of the silver cup type (1 cm. diameter) set in a small bar of plastic (6 × 2 cm.) and fastened by means of rubber bands around right forearm and forehead. The skin was prepared in the usual way with methylated spirits followed by the application of electrode jelly.

Results

The analyses of variance (Tables I and II) show no significant differences between the groups in either forehead or forearm tension during the conditions of rest and stimulation.

TABLE I

Analysis of Variance: Arm Tension Data

	df	m.s.v.	*F*	
Variance between persons				
Between groups	3	196.649	.731	n.s.
Within groups	70	269.184		
Total sum of squares: 19432.841	73			
Variance between periods				
Between periods	6	406.984	51.68	signif.
Within periods	40	7.875		
Total sum of squares: 2756.911	46			

TABLE II

Analysis of Variance: Forehead Tension Data

	df	m.s.v.	*F*	
Variance between persons				
Between groups	3	15.690	.407	n.s.
Within groups	69	38.534		
Total sum of squares: 2705.949	72			
Variance between periods				
Between periods	6	76.657	82.34	signif.
Within periods	40	.926		
Total sum of squares: 491.171	46			

The *F* ratios obtained from the "conditions" analysis, however, indicate that tension levels are significantly affected in all groups by the change in experimental conditions. A large part of the variation can be attributed to muscular innervation occurring in response to the questioning procedure. Between the rest periods themselves, however, changes in tension levels were observed. All pre-questioning rest periods were compared with combined post-questioning rest periods: a significant drop in forehead tension ($t = 3.725$) but not in arm tension was found. Final "informed" relaxation (period *g*), before which subjects were told that the

experiment was near conclusion, is significantly lower than initial resting level (period *a*); arm $t = 5.599$, forehead $t = 13.00$.

Correlations between Frontalis and Forearm Tension

The correlations between the two tension areas in the different conditions are as follows ($N = 72$):

Rest period (*a*): +.158
Questioning (*e*): +.062
Rest period (*g*): +.126

These coefficients do not reach an acceptable significance level, and confirm previous results pointing to independence of the two tensional areas.

Further correlations were calculated to determine the reliability of the separate tension measurements from one period to another. The results are given in Table III. All correlations are significant, and indicate high reliability of forehead measurement, and a somewhat lower forearm reliability. It should be noted that the two rest periods were separated by only 11 minutes.

TABLE III

RELIABILITY OF TENSION MEASUREMENTS

Location	Conditions	*r*	*N*
Forehead	Rest (*a*) with questioning	+.675	72
	Rest (*a*) with rest (*g*)	+.806	72
Right forearm	Rest (*a*) with questioning	+.672	74
	Rest (*a*) with rest (*g*)	+.518	74

DISCUSSION

The measures of muscle tension obtained do not differentiate either neurotics from normals, or introverts from extraverts, when subjects with extreme scores on neuroticism and introversion-extraversion questionnaires are selected and tested. This conclusion applies to two experimental conditions: (i) relaxation, and (ii) verbal responding to a questionnaire.

The validity of the questionaires may first be considered. Two kinds of validity are involved: that of an external criterion (for example, psychiatric classification) and the internal validity derived from statistical refinement and analysis of the scales in conjunction with other objective tests. In the latter case, a "valid" test could emerge which might bear an imperfect relation to psychiatric diagnosis, but which could be used as a

criterion measure to test certain predictions (5). Evidence has been presented, nevertheless, of a positive relationship of the questionnaire scales (particularly neuroticism) to psychiatric diagnosis (2). Further research into the relationship of the measures to other criteria is obviously required.

One conclusion which might be drawn is that the basis of clinical (psychiatric) assessment along such dimensions as normality/neuroticism or anxiety state/hysteria may differ in important respects from that of questionnaire assessment. While the latter may measure relatively stable characteristics, psychiatric opinions are usually formed on the basis of acute emotional behaviour. This factor of acute disturbance may be particularly relevant when physiological responsiveness is being determined.

It would seem desirable to repeat the experiment on further groups of psychiatric patients, both to check on the tension results, and to determine the relationship between the clinical categories and the dimensional measures.

The positive findings in the present data are of interest, though not specifically relevant to the main problem. They are that, during the act of speaking, highly significant increments in frontalis (forehead) and forearm tension are observed. This occurs even though no overt movements apart from lower facial ones are required. Whether such increases accompany speaking *per se* or occur only when the situation is slightly "stressful" to the subject cannot be determined on the available evidence. Wallerstein (14) has reported gradients in forehead and chin tension during listening, relating his results to a central factor of organization or comprehension.

A high level of frontalis tension obviously characterizes states other than those of manifest anxiety; conversely, subjects in the present experiment scoring high on the neuroticism questionnaire (i.e., complaining of feeling anxious, worried, etc.) are not significantly more tense than those with low scores. Additional factors could be, for example, a high degree of alertness, attention, or preparedness to act, perhaps distinguishable from so-called excessive neurotic preparatory tension in that relaxation occurs more readily during task intervals, or in so far as differential mobilization to differing tasks can be demonstrated. The work of Kennedy and Travis (9, 10) is interesting in this context since these authors point to a relationship between diminishing tension in supraorbital muscles and decreasing level of alertness (sleepiness?) during performance of a continuous task.

As Malmo and Smith (11) point out, it is doubtful if any theory of muscle innervation in psychiatric disorder will be adequate unless account is taken of changes accompanying "cognitive" acts. Physiological innervation accompanying cognitive acts may be quite large, and this must

complicate any theory which relates autonomic and somatic responses to such concepts as anxiety, and places such emotional states at one end of a single dimension of activation.

Far greater experimental knowledge and refinement of both physiological and "personality" measurements are required before adequate links between the two can be forged.

Summary

1. Muscle tension of the frontalis and right forearm extensor muscles was assessed electromyographically in 75 university students selected on the basis of extreme scores on neuroticism and introversion-extraversion questionnaires to provide four groups: (i) introverted neurotics, (ii) extraverted neurotics, (iii) introverted normals, (iv) extraverted normals.

2. No significant differences in tension levels were observed between groups, either during relaxation or during verbal response to a series of questions.

3. All groups manifested significantly higher tension levels while being questioned. Final resting tension level was significantly lower than initial levels.

4. The relationship of the questionnaire assessment of neuroticism and introversion-extraversion to psychiatric classification was considered and the need for further validation studies was stressed.

5. Fairly high consistency of measurement was obtained for forehead tension; reliability of arm measurement was somewhat lower but still significant.

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VISUAL HALLUCINATIONS DURING PERCEPTUAL ISOLATION[1]

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RECENT STUDIES in which humans have been subjected to one or another form of confinement have reported the occurrence of various kinds of visual hallucinations (1, 2, 3, 4, 6). The descriptions of these hallucinations vary so greatly that for convenience we have classified them into a three-fold system as follows. Flashes of light, flickering lights, dim glowing lights, etc., which lack shape and usually appear in the visual periphery we call Type I hallucinations. Hallucinations of definite shape which are geometric in nature (squares, circles, rectangles, lattice-work, etc.) we call Type II hallucinations. Type III hallucinations (which did not occur in the present study) are reports of highly structured integrated scenes which sometimes are even animated. It will be suggested later that the type of hallucination which results from confinement is related to the nature of the confinement conditions.

METHOD

The type of confinement utilized in the present study has been termed sensory deprivation, and two different kinds were employed. In the first, called Phase One, confinement conditions were as follows. Subjects were confined in a small, dark, light-proof, sound-proof cubicle for 72 hours. They were fitted with moulded ear plugs and cardboard gauntlets which extended slightly below the fingertips. The cubicle contained a bed. Each 24 hours of confinement was interrupted three times to provide meals and attend to toilet needs. Meals were conducted quietly in the darkened cubicle, but for toilet facilities it was necessary to leave the cubicle and go down a long hall. For this trip Ss were blindfolded and led by the experimenter. There were never fewer than two trips per day, and we later learned that the blindfold was faulty in that all Ss reported light leaks. At the time we considered this of minor consequence. Eleven Ss were confined under these conditions. Two of them requested release in the first 24 hours, leaving nine effective Ss.

Since deprivation under Phase One conditions was obviously of less than maximum severity, the confinement conditions were altered to permit a second and more rigorous study which will be referred to as Phase Two. In Phase Two the Ss remained in the dark cubicle for the entire duration of the confinement. Meals were self-regulated from a portable ice-box; toilet needs were met by relief bottles and a chemical toilet. Eleven Ss served under Phase Two conditions, five being confined for 72 hours, three for 48 hours, and three for 24 hours.

[1]This research was conducted under contract DA-49-007-MO-671 between the Office of the Surgeon General of the United States and Princeton University.

The incidence of hallucinations in both studies was determined in a post-confinement interview, when each S recorded a full description of his experiences in sensory deprivation. There was little timidity on the part of Ss and their descriptions were rather lengthy. At the end of any description which contained some item which could have been an hallucination, a day dream, or a bit of vivid imagination. If there item had been an hallucination, a day dream, or a bit of vivid imagination. If there was no mention of an hallucination during the interview the experimenter specifically asked about such occurrences. If S denied having hallucinations, he was assured that no stigma attached to such perceptions and was given descriptions of some typical hallucinations. Phase One Ss were asked to estimate at what point during confinement the hallucinations had occurred. They were able to do so with some confidence since they could estimate elapsed time fairly well by counting meals. As it turned out it was unnecessary to ask Phase Two Ss when their hallucinations occurred.

The final identification of hallucinations (for there were a few doubtful cases) was performed by two independent judges who listened to the recorded protocols and then made their judgments. To qualify as an hallucination the experience had to have an "out-thereness," its appearance and disappearance had to be independent of Ss volition, and S, at least at the beginning, had to be convinced of its reality. This procedure may have been more elaborate than was necessary, but in any event the data presented in Tables I and II represent perfect agreement between the two judges.

TABLE I

NUMBER AND TYPE OF HALLUCINATIONS REPORTED DURING SENSORY DEPRIVATION

Hours of confinement	24			48			72		
Type of hallucination	I	II	III	I	II	III	I	II	III
Phase I ($N = 9$)	2	1	0	3	2	0	4	3	0
Phase II ($N = 11$)	0	0	0	0	0	0	1	0	0

RESULTS

From Table I it can be seen that Phase One conditions of sensory deprivation produced many more hallucinations than did the more rigorous Phase Two. Six of the nine subjects in Phase One experienced hallucinations. The one hallucination reported by Phase Two subject was easily located in time since it occurred only a few hours before release. Although there may be some question about this single positive report from Phase Two, there can be little doubt that the remaining 10 subjects had no hallucinations whatever.

The distribution of hallucinations among those of the Phase One subjects who experienced them is shown in Table II.

From the data reported in Tables I and II it is clear that the conditions of confinement which permitted more sensory stimulation also produced

the greater number of hallucinations. There seems also to be a relationship between length of confinement and number of hallucinations, with a slight increase in each type of hallucination as the length of confinement increases (Table II).

TABLE II

NUMBER, TYPE, AND TIME OF EACH HALLUCINATION REPORTED BY 6 PHASE ONE SUBJECTS*

Hours of confinement	24			48			72			Total hallucinations per subject
Type of hallucination	I	II	III	I	II	III	I	II	III	
Subject										
10	0	0	0	0	0	0	1	1	0	2
9	0	0	0	2	0	0	0	0	0	2
8	0	0	0	1	0	0	1	0	0	2
5	0	0	0	0	0	0	1	1	0	2
4	0	0	0	0	0	0	1	1	0	2
1	2	1	0	0	2	0	0	0	0	5
Totals	2	1	0	3	2	0	4	3	0	15
GRAND TOTAL		3			5			7		

*Subjects 2, 3, 6, 7, and 11 reported no hallucinations and are omitted. (Subjects 3 and 11 dropped out after 11 and 18 hours respectively.)

DISCUSSION

Other studies of the effects of confinement conducted at McGill University (2, 3, 4) report not only a more frequent occurrence of hallucinations but also the occurrence of Type III hallucinations, not seen by our subjects. The confinement conditions in the McGill studies differed in two significant ways from ours. First, the subjects were confined for a longer time; second, and probably more important, they were confined in an illuminated cubicle, wearing semi-translucent goggles "which transmitted diffuse light but prevented pattern vision" (3, p. 71). The work of Hochberg *et al.* (5) suggests that diffuse light in the absence of pattern vision is itself sufficient to produce hallucinations. Hochberg was investigating colour adaptation in a homogeneous field, using table tennis balls carved to fit the eye socket. The stimuli were projected through the celluloid hemispheres. Under these conditions subjects frequently reported the presence of forms and shapes, even insisting at times that they were part of the experiment.

Thus it would appear that confinement which allows no visual stimulation, such as our Phase Two sensory deprivation, produces a minimum of hallucinations. Confinement that allows a slight amount of light stimulation may produce some hallucinations, but these are simple affairs, restricted to what we have called Types I and II. Confinement permitting a great deal of visual stimulation, but not pattern vision, produces not only the greatest number but also the greatest variety of hallucinations. There are also some indications that, regardless of confinement conditions, the longer the confinement the greater the probability of hallucinations.

In an earlier study (7) from this laboratory there were, surprisingly, no reports of hallucinations when four subjects were confined for 48 hours under conditions very similar to those of Phase One. The major difference in the confinement conditions of that and the present studies is that the earlier study allowed the subjects to eat by a dim red illumination (15-watt bulb) which permitted pattern vision for three short periods each day.

Summary

A total of 20 subjects were confined for periods of up to 72 hours under two conditions of sensory deprivation, one more rigorous than the other. A number of visual hallucinations were reported under conditions permitting occasional brief light stimulation, but only one when no such stimulation was possible.

On the basis of this and other findings it is suggested that: (*a*) the greater the reduction of stimulation the less the likelihood of hallucinations, and (*b*) with increasing visual stimulation (short of pattern vision) not only the number but also the complexity of visual hallucinations may increase.

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BREED DIFFERENCES IN THE DOG'S EMOTIONAL BEHAVIOUR[1]

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THE PURPOSE of the present study was to extend the investigation of constitutional factors in emotional behaviour, and to relate these to the factors of experience. A number of studies have established that wildness, aggressiveness and emotional instability involve genetic factors; but these have dealt with rodents only (1, 2, 3, 4, 5, 6, 10, 11, 12, 13, 14), and have not investigated the relation to experiential variables. Since some of the complexities of motivation which are of most interest in man do not appear clearly in the lower mammals, it would be desirable to make such studies with primates, but it is impracticable to do so because genetically pure strains of monkeys or apes cannot be developed in any reasonable period of time. In the dog, however, we have already available a considerable (though far from complete) purification of diverse genetic strains. The dog also shows some of the motivational complexities to a much greater extent than the rat or mouse. The pure-bred dog, therefore, presents an exceptional opportunity for further study of the interaction of constitutional and experiential variables in the determination of some of the features of "higher" motivations.

The present experiment dealt specifically with the patterns of emotional behaviour in dogs of different breeds. It has already been shown that dogs exhibit "irrational" fear at the presentation of a wide range of innocuous but strange objects (7, 8). The same method was used to establish whether susceptibility to such fears would differentiate between ten pure breeds of dogs. At the same time, an opportunity to clarify some aspects of the interaction between the type of environment at maturation and subsequent emotional behaviour was provided by comparing (for two breeds) dogs raised under varying degrees of perceptual deprivation. In this manner it was possible to learn something about the way in which heredity and experiential factors interact to produce distinctive patterns of behaviour within the same species.

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Method

Subjects and Treatment

The subjects studied were 230 pure-bred dogs representing 10 different breeds. Of these, 202 were raised and lived as pets in private homes; 20 were born, reared and maintained under the standard conditions of breeding and show-kennels; and 8 were raised in the McGill laboratory in a drastically reduced perceptual environment. Table I gives a description of the subjects. The breeds were selected on the basis of their availability in sufficient numbers among the dog population in the city, and for each dog a certificate of registration with the Canadian Kennel Club served as evidence of the purity of the breed. In order to secure as representative a sample as possible no two dogs had the same parents, and different breeders' stocks were represented in every breed.

TABLE I

Breeds, Numbers, Ages, and Sexes of Animals Tested

Breed	*N*	Age in months		Sex	
		Mean	Range	M	F
HOME-REARED GROUPS					
Bedlington terrier	14	30.7	12–71	8	6
Boston terrier	20	50.1	15–120	6	14
Boxer	30	34.5	8–96	13	17
Collie	16	34.4	7–84	4	12
Welsh corgi	15	45.7	12–120	6	9
Dachshund	30	40.3	7–108	15	15
German Shepherd	11	31.3	12–72	4	7
Standard poodle	24	42.9	10–96	8	16
Miniature poodle	28	27.8	9–72	14	14
Scottish terrier	14	34.3	10–84	1	13
RESTRICTED GROUPS					
Scottish terrier (lab-free)	10	35.6	14–72	8	2
Scottish terrier (cage-reared)	8	26.3	14–48	2	6
Boxer (kennel-reared)	10	35.6	16–72	7	3

All dogs in the home-reared groups were acquired as pets between six weeks and three months of age, and their living conditions were found to be surprisingly homogeneous. Good physical care was taken of all the dogs concerned. Since all were valuable animals, they were never let out of sight in the streets, and there was little opportunity for the dog to have experiences not known to the owner. No differences, as between breeds, were found in the type of training received. All dogs were essentially maintained as house pets, whether they belonged to a large-sized

hunting breed or to a small lap-dog breed. Differences with respect to the presence or absence of other dogs or young children in the home were randomly distributed among the 10 breeds.

The 20 kennel-reared dogs were adequately cared for, treated gently, but not made pets of. These dogs were exposed to other dogs and were allowed to run free for several hours a day while the rest of the time was spent in cages. In comparison with home-reared animals, however, their environment was limited in most respects.

The eight cage-restricted dogs were reared in isolation from other dog and human contacts, with visual experience drastically reduced for a period of eight initial months (7, 8). Testing was carried out three and two years after isolation for two dogs, and three months after isolation for the remaining six.

Testing Procedure

All the dogs in the free environment were tested in their homes, in the presence of the owner. Similarly, kennel-reared dogs were tested individually in their runs or in a familiar room in the presence of their caretaker. Cage-restricted subjects were all tested in the laboratory in one empty room with which they were reasonably familiar.

After a period of approximately 15 minutes, during which the dog's previous history was obtained from the owner, the subjects were presented with the following objects: (1) a mechanical snake which slithered a distance of about two feet; (2) a balloon, inflated in front of a dog to approximately 12 inches diameter; (3) a musical top; (4) a medium-sized umbrella, opened suddenly about a foot away from the dog. The fifth object was a hallowe'en mask, which the owner was directed to put on, then turn suddenly towards the dog and call it in the usual friendly manner. These objects were presented for approximately 10 seconds each in a fixed order to all the subjects. The test objects were picked from those used by Melzack (7, 8) for their effectiveness in eliciting fear and for their convenient size.

No attempt was made to counterbalance or randomize the order of presentation of various test objects, since the main concern was the investigation of breed differences in emotional disturbance.

Treatment of Data

Detailed records of behaviour were made during testing, without interpretation. Later, in evaluating the experimental observations, six classifications of behaviour were made: (*1*) *no response* (N); (2) *curiosity* (C): brief investigation of the object; (3) *teasing* (T): immediate and excited approach to, and seeking contact with, the object, worrying and teasing it; (*4*) *approach-avoidance* (AA): excitement with alternating approach and avoidance, stalking and keeping the object well within reach; (*5*) *wariness* (W): tenseness and trembling of the body, keeping an eye on the object from a safe distance, frequently accompanied by growling; (*6*) *avoidance* (Av): clear-cut avoidance and escape from the test situation. Each dog could contribute a total of five responses, and the scoring consisted simply in categorizing a dog's behaviour in terms of the six types of responses described above.

It should be made clear that only the initial reaction during the 10 seconds' presentation was recorded and classified. With longer presentation the initial reaction might well have given place to a different response; indeed, this actually hapened in a number of cases when, after testing was completed, the dogs were shown the same object again. Extreme avoidance gave place sometimes to wary exploration or (in fewer cases) to apparent lack of interest.

Experimental data were obtained in two stages, which makes possible some control of sampling bias. A first sample of 101 dogs, representing the 10 breeds, was obtained and analysed, and five months later a second sample of 101 dogs was tested. If the first sample was unrepresentative (for example, because the more accessible animals in one of the breeds were from a particular strain), this should be shown by a different pattern of results in the second sample, when the bottom of the barrel was approached. However, the second block of data showed no significant differences for any breed. Accordingly, the two sets of data were combined for the final analysis.

Results

The results fall into two parts: differences between the 10 breeds of home-reared pets; and, for two breeds, differences produced by varying degrees of restriction in rearing. Comparisons between breeds were made by means of 2-by-k chi-square tables, with respect to all six types of responses.

The most surprising finding was that the breeds differed significantly, not only in terms of susceptibility to fear, but also in terms of patterns of response in both fearful and non-fearful behaviour.

The 10 breeds differed with respect to five out of the six observed types of response. Only with respect to one non-emotional response, categorized as "curiosity," were no breed differences revealed (although significant differences were obtained for two *groups* of breeds referred to below). In all other categories differences were found between breeds which were significant at better than the .001 level of confidence (chi-square). The data for categories 3 to 6 are presented in detail in Table II.

In view of the individual differences observed in all 10 breeds, it seemed necessary to discover whether the variance between the groups contributed significantly more to the total variance than that found within the groups. An analysis of variance based on a non-parametric statistic, the *H*-test (9), was carried out for each type of response involving emotional disturbance. In all four types the *H*-values, after correction for ties, were statistically significant at better than the .001 level of confidence. These results substantiated the difference between the 10 breeds revealed by the chi-square method.

No significant relation was found between the two observed types of fearful responses, avoidance and wariness, or between the two emotional responses which did not involve fear: teasing and approach-avoidance. On the other hand, avoidance and teasing were negatively correlated (*rho* = −.68).

A rough idea of inter-breed overlap can be obtained from inspection of means and standard deviations computed for all breeds for the four

TABLE II

MEANS AND SDs OF FREQUENCIES OF 4 TYPES OF EMOTIONAL RESPONSE FOR 10 BREEDS OF DOG (HOME-REARED)

		Avoidance		Teasing		Appr.-avoid.		Wariness	
Breed	*N*	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Collie	16	2.69	1.65	0.37	0.70	0.50	0.71	0.75	0.66
G. Shepherd	11	2.63	1.07	0.36	0.88	0.18	0.39	0.81	1.00
Corgi	15	2.40	1.23	0.06	0.25	0.20	0.54	1.33	0.94
St. poodle	24	2.29	1.40	0.33	0.83	0.71	1.00	0.96	1.00
Dachshund	30	2.10	1.25	0.36	0.71	0.33	0.70	1.20	1.16
Min. poodle	28	1.53	1.35	0.25	0.51	0.35	0.35	1.93	1.31
Bedlington	14	1.00	1.36	1.28	1.33	0.50	0.98	0.50	0.63
Boston	20	0.40	0.49	1.40	1.15	1.05	1.11	0.65	0.96
Boxer	30	0.36	0.71	2.43	1.52	0.43	0.80	0.66	1.13
Scottie	14	0.21	0.41	1.42	1.11	1.85	1.13	1.00	1.14
χ^2		108.30		147.71		61.10		45.46	
P		.001		.001		.001		.001	

(χ^2 values are calculated on the basis of the total numbers of responses.)

types of response involving emotional disturbance (Table II). A more detailed description of the extent of overlap will be found below.

Comparison between the Fearful and Fearless Groups

When the distribution of the two fearful responses (Avoidance and Wariness) was analysed, two main groups of breeds emerged. One group was made up of working and hunting dogs (the "fearful" group) with high scores on avoidance and wariness responses: collies, German shepherds, miniature and standard poodles, corgis and dachshunds. The other ("fearless") group contained fighters, killers and ratters, with high scores on both teasing and approach-avoidance responses. Boxers and all three breeds of terriers belong to this group. It is clear that size differences were randomly distributed between the two groups.

The fearful and fearless groups (124 and 78 dogs respectively) differed on all four measures of emotional behaviour and also in the number of "curiosity" responses (on which single breeds did not differ significantly). The fearful group made significantly more avoidance and wariness responses than the fearless group, while the latter made significantly more teasing, approach-avoidance and curiosity responses. These differences, tested by chi-square, were significant at better than the .001 level of confidence.

Furthermore, within each group of breeds a further differentiation in the pattern of response was observed. Among the fearful breeds, some gave predominantly avoidance responses while others showed typically the "wariness" type of response. These differences were significant at better than the .01 level of confidence.

As might be expected, there was some overlap between the two groups, and its extent was measured as follows: animals giving three or more fearful responses (avoidance and wariness) out of five possible responses were arbitrarily classified as "fearful," those giving three or more fearless responses (teasing and approach-avoidance) as "fearless." How this division cut across breed groups is shown in Table III.

TABLE III

OVERLAP BETWEEN BREED GROUPS IN TERMS OF NUMBERS OF DOGS MAKING 3 OR MORE FEARFUL OR FEARLESS RESPONSES IN 5 TEST SITUATIONS

Breeds	Number of animals	
	Fearful responses (Av and W*)	Fearless responses (T and AA*)
Fearless		
Bedlington terrier	4	10
Boston terrier	3	17
Boxer	6	24
Scottish terrier	2	12
Fearful		
Collie	14	2
Corgi	13	2
Dachshund	27	3
German Shepherd	10	1
Standard poodle	21	3
Miniature poodle	27	1

*Abbreviations as on p. 44.

Age and Sex Factors

Age means for the 10 breeds ranged between two and four years. Analysis of variance used to test the significance of age differences gave an F-ratio of 1.72 with a p value greater than the .05 level of confidence. This does not reject age as a factor in emotional characteristics of the dog, but it will be shown that such age differences as existed did not

account for the breed differences observed in the present experiment. First, there was no difference in age between the fearful and fearless groups, the means being 37.8 and 37.1 months, respectively. Secondly, there was no significant relation between age and the number of avoidance and teasing responses which differentiated the two groups. In both groups, when the animals were divided into low and high avoiders or teasers, and point bi-serial correlations between age and number of avoidance or teasing responses were made, the coefficients obtained were far from being statistically significant.

There were 96 females and 134 males in all. Comparison of sex differences and their distribution in relation to the various types of responses gave chi-squares with p values above .05. As in the case of age, this does not reject sex as a factor in emotional behaviour of the dog, but it will be shown that such sex differences as existed did not account for the breed differences observed. First, there were no significant differences in the sex ratios between the two groups of fearful and fearless dogs (χ^2: 0.21 and 0.33, $p > .50$). Furthermore, comparison between the number of avoidance or teasing responses contributed by either sex within the fearful and the non-fearful groups gave insignificant results (χ^2 values ranging between 0.25 and 3.01, and p values ranging between .10 and .70).

However, quite different results were obtained when an attempt was made to discover whether sex can determine a difference in response patterns *within* the fearful and fearless groups. Although there were no significant sex differences in terms of non-emotional responses (N and C), avoidance, or wariness, a male-female comparison for the 10 breeds in terms of approach-avoidance responses revealed significant differences: a chi-square of 10.06 was significant at better than the .01 level. Breed by breed analysis revealed that male Boston terriers made more of this type of response than females (χ^2: 4.18, $p < .05$) and the same trend appeared in Scottish terriers. It would appear that the characteristic stalking in front of the object, accompanied by growling and barking, was the typical male response.

To summarize: significant breed differences were found in five out of six types of response. When the responses of the 10 breeds were analysed with respect to susceptibility to fear or lack of it, it was possible to distinguish two behaviourally distinct groups of breeds. Furthermore, within each of these two groups, significant differences were found in the patterns of fearful or fearless responses.[2]

[2]A possible objection must be considered: that temperamentally different persons tend to obtain different breeds of dogs, and that differential treatment by the owners might then result in apparent differences between breeds where no inherent differences existed. If this objection were valid, and the test results reflected differences

Effects of Perceptual Deprivation

Comparisons between dogs raised in free and restricted environments were made for two breeds. Data were obtained for 10 boxers and 18 Scottish terriers which had been reared with some degree of restriction. The results are tabulated in Table IV.

TABLE IV

PERCENTAGE FREQUENCIES OF 7 FORMS OF RESPONSE IN DOGS WITH VARYING DEGREES OF ENVIRONMENTAL RESTRICTION, SEPARATELY FOR 2 BREEDS

Breed	Percentage of responses						
	Av	W	AA	T	C	N	DE
Boxers							
Home-reared	7	13	9	49	15	7	0
Kennel-reared	28	0	4	26	10	32	0
Scottish terriers							
Home-reared	4	20	37	29	10	0	0
Lab-free	56	12	12	4	2	12	2
Cage-restricted	27	10	10	20	5	3	25

NOTE: first six abbreviations as on page 44; DE, diffuse excitement.

Comparison of the home-reared with kennel-reared (semi-restricted) groups revealed significant differences in the patterns of behaviour. The most striking effect of kennel-rearing was an increase in the number of avoidance responses and a decrease in the number of "typical" responses of the breed. Thus, kennel groups of both boxers and Scotties gave significantly more avoidance responses than home-reared groups (boxers: $\chi^2 = 12.22$, $p < .001$; Scotties: $\chi^2 = 29.8$, $p < .001$). They also made fewer teasing and approach-avoidance responses (boxers: $\chi^2 = 3.9$, $p < .05$; Scotties: $\chi^2 = 7.0$, $p < .01$). It should be recalled that both breeds belong to the fighting and teasing group, which, in the tests used in this experiment, made few avoidance responses.

The pattern of responses after severe restriction (cage-rearing) in Scotties was also significantly different when compared to that of the home and kennel-reared dogs. Cage-restricted dogs gave significantly more avoidance responses than home-reared pets ($\chi^2 = 10.76$, $p < .001$),

in the owner's behaviour, one would expect them to be at least as much influenced by the presence or absence of children in the home. However, when breeds were analysed, either as one sample or individually, with respect to the presence of children, the chi-square values obtained were so low that the probabilities of any statistical significance were negligible.

though less than kennel-reared dogs ($\chi^2 = 4.15$, $p < .05$). However, the most striking finding was that in the cage-restricted animals a different pattern of response emerged which could best be called "diffuse excitement"; this consisted in a heightened level of activity—urinating, defecating, running around the room—but without appearing to be responding to the test objects. The excitement, however, usually subsided on removal of the test object, giving place to more organized investigation of the experimenter and testing room.

A final observation refers to breed differences in the effects of early perceptual deprivation. It appeared that Scotties made significantly more avoidance responses than boxers ($\chi^2 = 4.66$, $p < .05$) when both breeds were reared in kennels.

Discussion

The results obtained with the restricted groups of dogs illustrate the complex interaction of constitutional and environmental factors in determining patterns of emotional behaviour. In a perceptually rich environment, boxers and Scottish terriers are similar in that they are both fearless and aggressive, though each breed has its own characteristic pattern of response. However, when reared in a more restricted environment, both breeds became more fearful and they no longer differed with respect to the pattern of response—though the quantitative difference referred to above (more avoidance by Scotties) still remained.

Data such as these allow us to separate two distinct sources of variance in behaviour, the constitutional and the experiential. When experiential factors were held constant (as between groups) and constitutional factors were varied, there emerged several sharply contrasted behavioural groups of dogs. On the other hand, wide differences were found to exist within a single breed of dogs when the animals were exposed to three types of environment with unequal degrees of perceptual experience.

Summary

The reactions of 202 normally reared dogs, of 10 breeds, to a series of strange objects were observed and classified, together with those of 28 further dogs, belonging to 2 of the same breeds, but with more restricted rearing.

Significant differences were found between breeds in six types of "emotional" responses, terriers and boxers being less wary and more aggressive than other breeds. This difference seems constitutional in origin, but did not appear when terriers and boxers were reared in a restricted environment.

The study attempts to clarify the relations between constitutional and experiential factors in behaviour, treating them as co-variants rather than independently.

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EFFECTS OF PERIPHERAL BLINDNESS ON EXPLORATORY BEHAVIOUR IN THE HOODED RAT[1]

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A NUMBER OF INVESTIGATIONS have shown that rats will demonstrate extensive locomotor activity when placed in a new stimulus situation, the amount of activity declining as a function of the length of time the animal remains in the situation (1, 8, 13, 14). Such *exploratory activity* is uncorrelated with the basal activity level as determined from the number of daily revolutions in an activity wheel (2, 14). Montgomery (15) and Montgomery and Segall (16) have further demonstrated that rats will learn a maze or solve a discrimination problem for the privilege of engaging in the exploration of a relatively complex maze. These data are perhaps related to the findings of Hebb and Mahut (12) and Havelka (10) who noted that some hungry rats consistently choose a long novel route to food rather than a short monotonous one.

Most explanations of these phenomena involve the postulation of an exploratory or curiosity drive aroused by external stimuli (4, 5, 9, 14). A somewhat different view of exploratory behaviour is implicit in Hebb and Thompson's (11) suggestion that such behaviour may be viewed as an attempt on the part of the animal to maintain an optimal level of excitement. The present study originated with the assumption that the optimal excitation level in a given animal is centrally maintained but is dependent on peripheral sense receptors for neural input and modification. Accordingly it seemed reasonable to assume that depriving the animal of one of its main sources of sensory inflow, such as vision, would modify the course and extent of exploratory activity. The specific hypothesis was that blind rats would demonstrate greater activity in an exploratory situation than sighted rats, since in the absence of visual input the blind rat would have to cover more territory to achieve the same level of central arousal by means of the remaining sense modalities.

Rhodes and Wyers (20) have recently reported that blind rats will show "increased saccharine consumption and more independent activity with a clicker device in comparison with a control group." They interpret these results in terms of a concept of optimal level of sensory input

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similar to that advanced above. To the best of my knowledge, however, there have been no prior studies of the effect of eliminating a specific sensory modality on exploratory behaviour.

Method

The subjects in this experiment were 28 male hooded rats from the Royal Victoria Hospital colony. They were 4 to 5 months old at the start of the experiment. Of the Ss 16 were enucleated under Nembutal; the remaining 12 served as controls.

Two situations were used to elicit exploratory activity: an open field and a Y-maze.

The open field test was carried out in a 48″ × 48″ × 12″ wooden box. The floor of the box was covered with white oilcloth divided into 25 9.6-inch squares. Illumination was provided by a single 100-Watt frosted bulb 5 feet above the floor of the field.

The Y-maze used was similar to that used by Montgomery (**13, 14**). All three arms were 24 × 4 × 3¾ inches and were covered by hardware cloth. Each arm was divided into two 12-inch segments. The maze arms were unpainted and were constructed of half-inch pine on a shellacked plywood base. The maze was illuminated by diffused natural light, supplemented in the late afternoon by overhead fluorescent lamps.

Procedure

On days 4 through 12 after the enucleation operation both the control and the experimental Ss were gentled for one minute every day. The Ss were first placed in the test situations on day 13.

To control for possible effects on Y-maze performance of open field experience and *vice-versa*, all Ss were further divided into two groups, with eight blind and six normal rats in each group. The Ss in Group I were initially run for three days in the open field and then, after a four-day interval, tested in the Y-maze situation. The procedure for the Group II Ss was the reverse.

All Ss received three 5-minute trials in the open field situation on successive evenings. The measure of activity was the number of squares entered by S in the test period. An S who placed his shoulders and forepaws in a square was considered as having entered it. Additional measures recorded were: grooms, rears, time to leave first square (latency), defecation and number of inside squares entered.

All Ss were given three 10-minute trials on successive afternoons in the Y-maze. Records were kept of the number of units entered by S during each of five 10-minute periods comprising a testing session. An S was credited with having entered a unit of the alley if he placed his head and forepaws within the unit. All Ss were initially placed at the end of one of the arms. Records of amount of defecation were also taken in the Y-maze apparatus.

Results

The results in Table I show that the blind Ss engaged in significantly more exploratory activity than the sighted Ss in both Y-maze and open field situations. Further analysis of the data showed that previous

TABLE I

MEAN EXPLORATORY ACTIVITY PER SESSION FOR BLIND AND SIGHTED RATS, WITH SIGNIFICANCE OF GROUP DIFFERENCES

Test	Group	*N*	Mean exploratory activity/session	S.D.	*t*
Y-maze	Blind	16	59.9	9.6	1.9*
	Sighted	12	50.2	17.4	
Open field	Blind	16	63.4	18.5	3.4**
	Sighted	12	35.7	24.8	

*$P < .05$ (one-tailed test)
**$P < .01$ (one-tailed test)

experience in the open field had a facilitating effect on the mean exploratory activity of the blind Ss in the Y-maze ($P < .02$), while similar experience had no significant effect on the Y-maze exploratory activity of the sighted controls. Similarly, previous experience in the Y-maze situation increased the exploratory activity of the blind Ss in the open field ($P < .01$), but again had no significant effect on the activity of the sighted controls. With the sample sizes utilized on the present study, this prior experience was essential to the demonstration of significant differences between blind and sighted groups.

As may be seen in Table II, blind Ss differed significantly from sighted Ss on three other measures of open field behaviour. Prior Y-maze experience did not appear to affect these measures for either blind or sighted Ss. Blind Ss were not found to differ significantly from sighted Ss in amount of defecation in the Y-maze situation.

Blind and sighted Ss show significant declines in exploratory activity both within-days and between-days in the Y-maze. These results are graphically shown in Figure 1. The within-days decline is significant

TABLE II

PERFORMANCE OF BLIND AND NORMAL RATS ON VARIOUS MEASURES OF OPEN FIELD BEHAVIOUR

Group	*N*	% Inside squares	Mean* rears	Mean grooms	Median** latency	Mean defecation
Blind	16	11.3	34.4	8.0	3.0″	6.1
Normal	12	3.4	23.7	7.6	12.5″	5.4

*t significant at better than .01 level of confidence (two-tailed test).
**Non-parametric median test significant between .05 and .02.

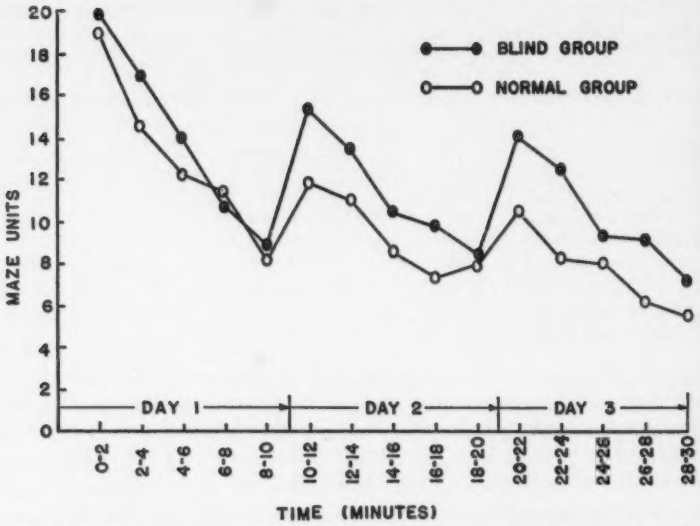

FIGURE 1. Exploratory activity of blind and sighted rats as a function of time.

at the .05 level or better for both blind and sighted *Ss* on all days, using a *t*-test for correlated means and comparing activity in the first two minutes with activity during minutes 8 to 10. Between-days, blind *Ss* drop from a mean of 70.2 units explored on day 1 to a mean of 52.4 units explored on day 3. Similarly, sighted *Ss* fall from a mean of 65.0 units to 38.25 units. *T*-tests for correlated samples lead to rejection of the null hypothesis at $P < .01$ in both groups.

DISCUSSION

The general results obtained in this study are compatible with the hypothesis that blind rats will explore more than sighted controls. The results of the open field test are of particular interest in view of Willingham's (22) factorial study of open field behaviour in mice. Thus, the blind *Ss* differed from sighted *Ss* in total number of squares covered, percentage of inside squares entered, latency, and "rears." These four measures constituted the open field portion of Willingham's "Factor II," which he suggested might be subsumed under the general category of "gross bodily activity."

One result not predicted, however, was the highly facilitatory effect of prior experience in one situation on subsequent exploratory activity of the blind *Ss* in a different situation. The simplest explanation of this

finding would be in terms of the time elapsed between the enucleation operation and testing in the two situations. The 13 days intervening between the operation and exposure to the first test situation, however, appeared sufficient for complete recovery from any general deleterious effects of the operative procedure. It might alternatively be suggested that this effect was due to initial nervousness of the blind *Ss*, and that this was alleviated by experience in the first exploratory situation. This, however, is not in accord with either *E*'s qualitative impressions or the data on emotional defecation. After the nine days of gentling the blind *Ss* appeared to be fully as tame and "calm" as the controls, and there was no significant reduction in defecation, which would have been expected if the effect of prior experience was simply to reduce nervousness. A third explanation requires the assumption that in the absence of visual stimulation over a 13-day period there was a reduction in the optimal excitation level of the blind animals. The subsequent exposure of these animals to a new and highly stimulating environment may then be thought of as reinstating an optimal level of excitation more closely approximating that prior to blinding. This would, in turn, account for the increased activity of the experienced blind animals according to the general hypothesis advanced earlier. Certainly, the susceptibility of the optimal excitation level to modification as a result of extreme changes in levels of environmental stimulation would appear a fruitful subject for empirical study.

The consistent within-days and between-days decrements in the exploratory activity of both blind and sighted *Ss* in the Y-maze situation lend support to Berlyne's attempt to place exploratory behaviour within a Hullian framework; the within-days decline can be referred principally to I_r, while the between-days decline, with some degree of spontaneous recovery, may be attributed to the build up of ${}_sI_r$ and the dissipation of I_r respectively. A neurophysiological basis for these phenomena may be sought in the habituation experiments of Sharpless and Jasper (**21**). These workers have demonstrated that with repeated presentation an auditory stimulus loses its ability to arouse the brain stem reticular formation; this appears to be functionally similar to the apparent decline in "excitation power" of the open field or Y-maze situations as measured by the amount of gross movement evoked by these situations.

It is the writer's belief that the optimal level of excitation concept, as put forth by Hebb and Thompson (**11**), may prove of considerable heuristic value in developing a general framework for the consideration of externally elicited drives. With further work it should be possible to utilize "optimal excitation level" as a unifying intervening process, anchored securely to behavioural variables, and with the additional advantage of having potentially testable neuro-physiological content. The

recent experiments of Olds and Milner (17) and Olds (18), demonstrating "reward areas" within the rat's brain, may eventually be of particular value in understanding the physiological substrate of exploratory behaviour. At least two similarities may be noted between reward by electrical stimulation and the rewarding effects of exploratory behaviour, both of them contrary to the generally accepted canons of drive reduction. First, as Montgomery and Segall (16) have noted in regard to exploratory activity: ". . . the reinforcement probably consists in an increase in the strength of the exploratory drive rather than a decrease as would be expected from drive-reduction theory." This situation is reflected in its extreme by some of Butler's monkeys who demonstrated apparently insatiable exploratory behaviour when placed in a situation permitting 10 hours of visual exploration daily over a 6-day period (7). This "insatiability" of exploratory behaviour is functionally very similar to the almost insatiable responding behaviour of rats for electrical reward (3), and is contrary to the effects of primary reward (e.g., food) on primary drive (e.g., hunger). Second, the operations which we ordinarily use to increase primary positive drives, namely deprivation, are generally ineffective in both exploratory behaviour (14) and electrical reward.

These considerations suggest the possibility that the rewarding effects of exploration may be due to neural activity in the various sub-cortical structures comprising Olds' "reward systems" (18). In recent reports Olds (19) and Brady (6) have noted that rewarding effects may be obtained from the electrical stimulation of certain portions of the midbrain reticular formation. Since a common feature of all novel stimuli is their ability to arouse the ascending reticular formation (21), there would appear to be some *ad hoc* evidence for the above line of speculation although future experimentation will have to determine how far this notion corresponds with reality.

Summary

Sixteen peripherally blind rats and twelve sighted rats were tested for exploratory activity in two different situations (Y-maze and open field). The blind rats were found to engage in a greater amount of exploration than the controls, although this difference only reached statistical significance after previous experience with one or the other of the test situations (owing to the differential effects of prior testing on the two groups). The results are interpreted in terms of the concept of "optimal level of excitation" advanced by Hebb and Thompson (11), and a possible neurophysiological basis for such exploratory activity is suggested.

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COMPUTING ΣX^2, ΣY^2 AND ΣXY

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THE PRINCIPLE of this method of computation underlies statistical machine procedures. Its advantage lies in the fact that, given a scattergram, it involves mere addition and therefore requires at most an adding machine of the simplest kind.

PART A

Variable X

Variable Y	1	2	3	4	5	6	7	8	9	f	c_1f	c_2f
9						1	1	2		4	4	4
8					2		2	1	2	7	11	15
7				2	1	3	3	2	1	12	23	38
6		2	1	1	4	5	1	1	2	17	40	78
5		2	2	4	6	3	1	2		20	60	138
4	3	1	3	2	4	2	2			17	77	215
3	1		1	3	3	3			1	12	89	304
2	1		1	2	2		1			7	96	400
1		1		1	2					4	100	500*
										100	500	2884
f :	5	6	8	15	24	17	11	8	6	N	ΣY	ΣY^2
c_1f :	100	95	89	81	66	42	25	14	6	518	ΣX	
c_2f :	518*	418	323	234	153	87	45	20	6	3090	ΣX^2	

*This value to be added only once, the other values in the column (or in the row) to be added twice.

Both scales of scores (X and Y) are made to start at unity for the lowest category and to rise by one unit for each successive category. The sums obtained can easily be converted into terms of original scores, if necessary.

For each variable (see part A): (a) compute f's, the sum of these giving N; (b) cumulate these f values downward (i.e., from the highest

category to the lowest), the sum giving ΣX or ΣY; (*c*) cumulate downward a second time, the sum of all numbers taken *twice* (except the category 1 number, which is added only *once*) giving ΣX^2 or ΣY^2.

PART B

					1	1	2				
				2	1	3	3	2			
			2	3	4	6	5	3			
		2	1	3	7	9	7	6	5		
		4	3	7	13	12	8	8	5		
	3	5	6	9	17	14	10	8	5		
	4	5	7	12	20	17	10	8	6		
	5	5	8	14	22	17	11	8	6		
	5	6	8	15	24	17	11	8	6		
Downward cumulation for Y:	17	27	33	62	108	92	67	56	38	:	500 ΣY
Leftward cumulation for X:	500	483	456	423	361	253	161	94	38	:	2769 ΣXY

For ΣXY (see B): (*a*) cumulate the whole scattergram downward, line by line, and compute column totals, the sum of these totals, if desired, giving ΣY; (*b*) cumulate this line of totals, *leftward* (i.e. from highest category to lowest), the sum giving ΣXY.

These sums are useful for computing Toops' L-values, standard deviations, correlation coefficients, simple regression coefficients, etc.

BOOK REVIEWS

The Dynamics of Interviewing: Theory, Technique, and Cases. By R. L. KAHN and C. F. CANNELL. New York: John Wiley & Sons, Inc. [Toronto: University of Toronto Press], 1957. Pp. x, 368. $7.75.

ANY EFFORT is commendable that seeks to counter the lack of definitiveness and the impressionistic approach that have characterized so much writing on the subject of interviewing. This volume represents such an effort. It is an ambitious attempt to integrate theory and research findings systematically, its focus being on the information-getting interview rather than on the therapeutic interview. It is particularly suited to the student, but should also prove valuable reading for the more sophisticated, whether in clinical psychology, personnel work, attitude research, or some other field of endeavour where the interview is used as a source of information.

Rather than presenting an entirely new theory on the subject, as the title might imply, the authors introduce familiar concepts into a relatively new setting by describing the information-getting process largely within a field-theory, client-centred framework. Drawing primarily upon the survey interview and assuming very little theoretical preparation on the part of the reader, the book builds upon the thesis that the interview is a unique interactional event whose outcome is multiply determined. This viewpoint is elaborated in the first section of the book, with particular emphasis upon the factors influencing respondent motivation and upon the motivating and measurement functions of the interviewer. The main sources of respondent motivation are felt to reside in the sense of understanding and acceptance which the interviewer conveys, as well as in the latter's ability to communicate how the interview contributes to and is congruent with respondent goals. Specific techniques for achieving these ends are discussed in some detail. The advent and control of biasing factors in interviewing are also given considerable attention, with reference being made to a number of pertinent studies.

Unfortunately, the role of non-verbal and subliminal cues is touched upon only indirectly, while no specific mention is made of the terminal handling of possible anxiety feelings that may be aroused by the interview. The first section of the book concludes with the description of a scale for rating interviewer effectiveness. The second section is given over to five full-length interviews with an accompanying critical commentary, exemplifying the principles and techniques described in the preceding section.

The subject-matter is presented in a lucid, well-organized manner, hampered only by occasional, minor misspellings. Clarification is aided by numerous examples and by a judicious use of repetition which at no point becomes tedious. The authors' knowledge of communication principles is reflected in the facility with which they present their material. However, whether the attempt to cover such a broad field of application detracts from the value of the book must remain a matter for speculation.

GORDON FILMER-BENNETT

Norfolk (Nebraska) State Hospital

Basic Readings on the MMPI in Psychology and Medicine. Edited by GEORGE SCHLAGER WELSH and W. GRANT DAHLSTROM. Minneapolis: University of Minnesota Press, 1956. Pp. xvii, 656. $9.50.

THIS VOLUME consists of sixty-six papers which, according to the editors, constitute the major research and clinical developments in the use of the MMPI during the last fifteen years. Some previously unpublished material on the derivation of the basic scales has been supplied by Hathaway, and some of the remaining material has been liberally edited. The papers are presented under ten section headings: Theory, Construction, Coding, New Scales, Profile Analysis, Diagnostic Profiles, Psychiatric Problems, Medical Problems, Therapy and General Personality. The editors present brief and generally somewhat superficial introductions to the sections, each of which is followed by a footnote indicating the sources of the material for the section being introduced. A suvey of these footnotes indicates that there is, in fact, much less original material in this volume than the authors' foreword might lead us to expect.

Undoubtedly, it is convenient to have so much pertinent material on the MMPI presented together in a single volume. In view of the inadequacy of the manual which accompanies the test, the bringing together of information about the construction of the scales is especially valuable. However, if the reader already has doubts about the value of psychological anthologies, this publication will almost certainly serve to strengthen them. In the first place, no attempt has been made to indicate the extent to which individual articles have been subjected to the editorial axe. Secondly, the introductory sections provide little in the way of critical appraisal of the material which is presented. The editors' time might have been spent more profitably in providing psychologists with an account, both descriptive and evaluative, of the development of the MMPI and of the extent to which its subsequent employment in research and practice has revealed its potentialities and weaknesses. A sufficiently stimulating account might also have served,

more than the present book, to direct the reader's attention to the original articles. These weaknesses detract from the value of this text as a systematic contribution. However, as a source book for the busy clinician, it is a convenient and well-organized reference.

RICHARD H. WALTERS

University of Toronto

The Clinical Psychologist. By WILLIAM A. HUNT. Springfield, Ill.: Charles C. Thomas, [Toronto: Ryerson Press], 1956. Pp. xi, 201. $6.00.

A FORMER CHAIRMAN of the American Psychological Association's Committee on the Relation of Psychology to Psychiatry, William Hunt presents in this book three lectures directed at lessening the tensions between psychiatry and clinical psychology in a clear, comprehensive and relaxed survey of the training, competence and contribution of people appropriately identified as clinical psychologists. As a man who has grown up with and helped develop clinical psychology, he should be listened to. He should be listened to by incoming students particularly, especially those who feel that clinical psychology was always structured, integrated, and had no problem of "role." Although written for other professions, it is a good, short and factual statement of the past and present, and a reasonable guide for the future, that should educate, sober and encourage those within the field. Psychologists will want to pass it along to their professional colleagues when they have read it and assessed how well they measure up to his definition. It may be that medical colleagues may feel that this book is another attempt by psychologists to "sell" themselves (certainly the dust jacket does little to change such attitudes), but few who give it a serious reading can so classify this considered and moderate review. Without being unrealistic or ignoring the reasonable demands from others that clinical psychologists should identify their ground and show good cause why they should wear a clinical label, Dr. Hunt's book precludes any further need for clinical psychologists to dwell interminably on problems of role, in favour of getting on with the job.

R. W. Ross

Toronto General Hospital

Guidance in the Modern School. By HENRY B. MCDANIEL and G. A. SHAFTEL. New York: Dryden Press, 1956. Pp. xv, 526. $5.75.

THIS IS a very complete and practical reference book for the guidance counsellor. It covers such topics as: Basic Concepts of Guidance,

Guidance in the Elementary School, Guidance in the Secondary School, Basic Needs of Young People, Principles of Counselling, Assessing Student Abilities and Aptitudes, Group Work in Guidance, Evaluation of the Guidance Program, New Directions in Guidance.

The book is very readable and is filled with practical examples and illustrations. Every chapter contains a summary along with problems and projects. There is a good index at the end and a very complete bibliography. The appendix contains a complete sample counselling interview. There are also specifications for an occupational monograph and a series of self-tests by which the reader may test his knowledge of the guidance field.

Undoubtedly this book was planned as a textbook for college students and as such should be particularly helpful. It will also be of special interest to guidance directors and head counsellors since it should be an ideal book for in-service training of teacher-counsellors, especially at the secondary school level. This book might well find a place on every counsellor's bookshelf.

K. M. McINTYRE

Leaside Schools

The Social Psychology of Music. By PAUL R. FARNSWORTH. New York: The Dryden Press [Toronto: The Macmillan Company of Canada], 1958. Pp. xiv, 304. $4.50.

PAUL FARNSWORTH'S BOOK on the psychology of music is the culmination of thirty years' interest in the subject and has been awaited with considerable expectation. It is perhaps unfortunate that Leonard Meyer's work, *Emotion and Meaning in Music* (reviewed here in December, 1957), should have so closely preceded it. For, while Farnsworth has assembled a surprising and impressive number of researches, it is difficult not to contrast the peripheral nature of most of these with Meyer's direct and convincing answer to the central question, "What does music do, psychologically, to and for the listener?"

The comparison, however, is somewhat unfair. Meyer is a musician, trying to reveal to musical people the nature of their musical experience; his thesis makes brilliant sense but is not susceptible of proof or disproof. Farnsworth, on the other hand, writes as a scholar, a scientist, whose own convictions are seldom directly expressed and always subordinated to experimental results. What he tells us, clearly and interestingly, is how much is *known* about the human response to music, the roots of musical taste, and the nature of musical ability, and how much is still to be guessed at. Hence he is concerned primarily with the measurable aspects of his subject, and it is notorious that what can be

measured about, say, a Beethoven symphony is likely to be fairly superficial.

The unexpected adjective *social* in Farnsworth's title reflects the author's significant shift during a lifetime of study from mathematical theories of beauty and consonance to cultural ones, from physical explanations to social ones, from absolutism to relativism, and from heredity to learning. This is in keeping with the general trends in our discipline and elsewhere. At the same time he examines in some detail many of the theories he has come to reject, mathematical, physiological, and psychoanalytic. This makes his book a valuable history and summary of the ideas which psychologists and musicians have focused on this area, and of the researches which have supported or (more often) failed to support them. There is factual information and critical comment on a great number of relevant topics, and if the reader must also encounter such trivia as lists of programme choices by various symphony orchestras and the comparative vibrato rates of Schumann-Heink and Gigli—well, he may put it down to the conscientiousness with which Farnsworth has surveyed his field.

After fairly thorough chapters on scales, intervals, and melody, there follows one on the language aspects of music in which the author comes close to the central problems of artistic communication. Here again, however, his empirical orientation leads him away from the study of musical language *per se* and into investigations of the matching of musical selections with English adjectives such as "solemn" and "delicate" —a clumsy and indirect approach to the unique idiom of music. Chapters 6 and 7 are largely reprinted from his earlier book on musical taste, and the remainder deal with the nature of musical abilities, their measurement, and recent applications of music in industry and therapy.

Farnsworth has an encyclopaedic knowledge of his field, he writes engagingly, and his judgment is invariably sound. One could wish that he were less considerate in his treatment of amateurish notions and investigations, and that he would occasionally risk a generalization that goes beyond established facts. But this would be alien to his cautious, scientific attitude, and what he set out to do he has done extremely well.

Like all Dryden publications, the book is sumptuously produced and printed. There are copious notes, good indexes, and a glossary of technical terms. The many references, however, are given only in numbered notes at the end of the chapters, and the omission of any alphabetical bibliography is a serious inconvenience.

J. D. KETCHUM

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Psychological Statistics. By QUINN MCNEMAR. Second edition. New York: Wiley, 1955. Pp. vi, 408. $6.00.

THE FIRST EDITION of McNemar's textbook presented one of the best introductions to statistical methodology available to students of psychology. For the revised edition, McNemar has more than rewarmed the old, he has added much new material and made more lucid much of the old. Some of the statistical techniques which have been added are: Cochran's method for comparison of three or more correlated proportions, Fisher's exact factorial test for fourfold tables, Hotelling's test for the significance of the difference between correlations based on the same sample, the reliability of difference scores, Bartlett's chi-square test for independent variances, the Pitman-Morgan test for correlated variances, the discriminant function, and selected distribution-free methods. In addition, the discussion of statistical inference, chi-square and the choice of the proper error term in analysis of variance has been considerably improved. In fact, the discussion of the error term in the fixed constants, components of variance, and mixed models not only removes certain ambiguities contained in the earlier edition but also presents the most concise description of this topic available in a text. McNemar again, and quite rightly, warns us away from the Latin Square design unless there are impelling *a priori* considerations for concluding that all interactions are zero.

Inevitably there are certain techniques that one would have liked to have seen discussed in greater detail. Although Kendall's *tau* is mentioned, the computational procedure for calculating it is omitted. Kendall's coefficients of concordance and agreement are not treated. An unfortunate omission was the failure to indicate the method for testing the significance of the difference between adjusted means based on covariance analysis. Distribution-free methods are given only a side glance because their relative efficiency and merits are generally unknown. The Doolittle method for the solution of multiple regression problems is presented with little explanation as to what one is doing when performing the various component operations. Although the Doolittle method is probably the method followed by most experienced computers, it is difficult for the beginning student to understand and follow. Burt's method for calculating partial regressions and multiple correlations by hierarchical subtraction would seem to have pedagogical advantages over the Doolittle method, in that the underlying algebraic principles and computational procedures are readily taught and easily understood by a student with elementary algebra. But it is perhaps unreasonable to expect any statistics text to cover all one's favourite techniques.

One additional oversight might be mentioned. When $N_1 = N_2$, the significance of the difference between two independent variances is tested by means of their ratio. In an equal sample size, Fisher's z distribution or Snedecor's F is symmetrical and the .05 and .01 probability points correspond to the .10 and .025 probability points. However, when $N_1 \neq N_2$ this will not be the case, except in an approximate sense. Unfortunately, McNemar does not make the point that it is not entirely correct to double the tabled probabilities when the Ns are unequal. His example (pp. 246–7) leaves one with the impression that one could follow such a doubtful procedure in testing the significance of the difference between independent variances based on unequal Ns.

Finally, some will be surprised to see that McNemar appears to be on the side of the one-tail testers. Is this position compatible with the stringent standards that he has consistently advocated before one can justifiably conclude that a *genuine* experimental effect has been demonstrated?

In conclusion, the reviewer believes that McNemar's revised book is an outstanding volume. It is highly recommended for serious consideration to anyone looking for a statistics text suitable for students who do not have to be led through the subject by "easy steps."

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